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THE REPORT OF THE COMMITTEE ON THE ENGINEERING BUILDING.

There has just been made public a report by the committee in charge of the construction of the building which is to be the future home for the three great national Societies of Mechanical, Electrical and Mining Engineers. This building is now under construction and a perspective view from the architect's plans is presented herewith. On the following page is shown also plans of four of the principal floors of the building. We reprint the substance of the committee's report as follows:

The public competition instituted by the Joint Committee for the selection of architects for the planning and erection of the buildings presented by Mr. Andrew Carnegie for the American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, and the Engineers' Club, resulted in the presentation of 26 sets of plans for the building. After a careful examination of these plans, the committee appointed Messrs. Hale and Rogers and Henry G. Morse, associate, architects for the three engineering societies, and Whitfield & King, architects for the Engineers' Club.

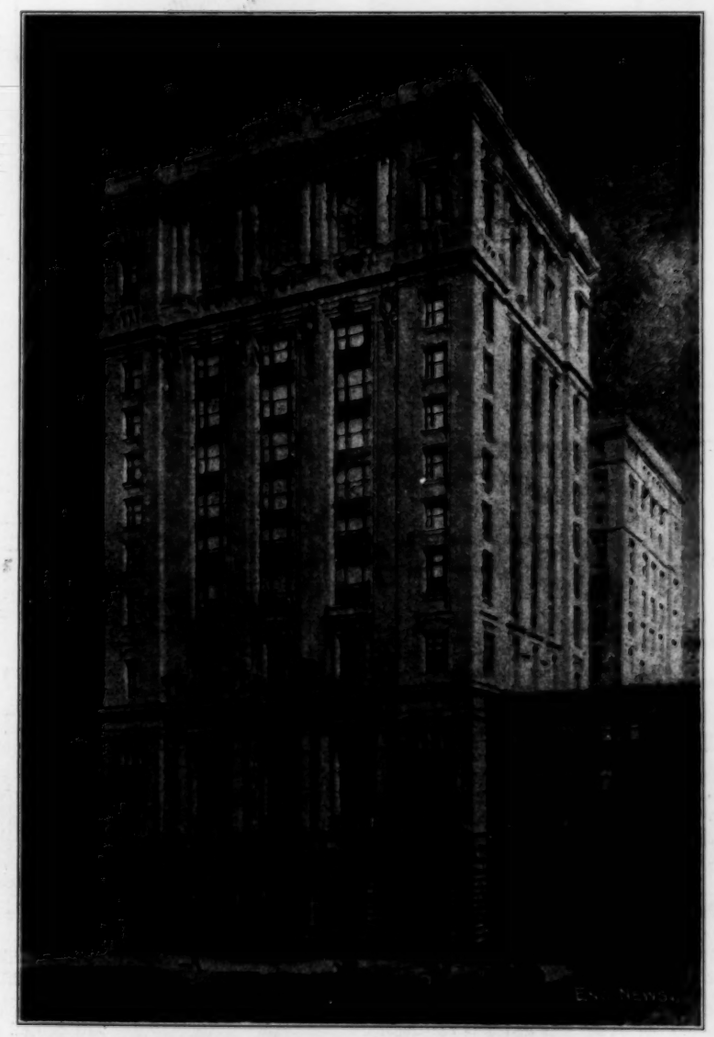
It will be recalled that the frontage of the Engineering Building on 39th St., between Fifth and Sixth Aves., covers five city lots, or 125 ft. front, and 100 ft. deep. The building utilizes 115 ft. of the 125 ft. front, and 90 ft. of the 100 ft. depth.

The Engineering Building must meet requirements in five directions:

1. It must serve the convenience of each of the individual societies, which enter the building as founders. This has been secured by a proposed arrangement which is represented on the society office floor plan herewith, not reproduced.

2. The building must supply to the three National Founder Societies and also to such other organizations as may be invited to participate in its benefits as associates, such meeting rooms and auditoriums as will be required for the annual meetings, the public reading and discussion of papers, and for scientific lectures and demonstrations. In view of the number of participant societies for which provision has been made, the committee have thought it advisable to arrange for a number of assembly rooms suitable for various uses.

One of these, primarily designed for the National Societies' meetings and for those of other large bodies, has been made to accommodate 1,000 persons. This limit is set as being as large a number as can be expected to hear clearly the voice of a speaker. The location of this large auditorium is on the first floor above the street, so as to make elevator service for it unnecessary. Attention is directed to the large foyer and generous corridors, which give ample space for withdrawal from the large assembly hall. The ample provision for exit also at the four corners of this floor is to be specially noticed as a desirable provision for safety. To enable auditors in the back of the auditorium to see clearly such diagrams and illustrations as may be on the stage the seats are arranged on a grade conforming to best modern practice in theaters. This parterre arrangement enables coat-rooms to be provided, opening from the outer corridors, and special consideration has been given to secure rapid service with large numbers in attendance. The large auditorium floor is reached from a great central rotunda on the street floor by generous stairways, and it can also be reached from carriages entering the driveway and moving continuously as they receive or discharge their passengers. The room for preparing apparatus and exhibits for the stage is conveniently served by a large freight elevator, so that heavy machinery and apparatus can be easily handled.



PERSPECTIVE VIEW OF THE ENGINEERING BUILDING FOR THE UNITED ENGINEERING SOCIETY, NEW YORK CITY.
Hale & Rogers, Architects; Henry G. Morse, Associate.

On the floor above the large auditorium are two assembly rooms occupying the principal portion of the area. These assembly rooms may be used independently for lecture purposes, or one may be made auxiliary to the other and used as a foyer or conversation room. As to the two rooms adjoining they may be used in common when desired, as, for instance, for purposes of general reception or conversazione. Auxiliary smaller rooms on this floor are provided, and provision is made for the service necessary for light refreshments or luncheon.

On the floor above a number of small lecture halls are provided suitable for ordinary meetings of scientific and engineering societies, and for meeting of sections at the time of the general conventions of national organizations.

It is expected that there will be a great demand, especially for the small meeting rooms, for scientific purposes. They will be supplied with electric current, with compressed air and with gas and water. The meeting rooms of all sizes will be fitted for the use of the projection lantern, and will be unique in their completeness for the purposes for which they are intended. The board rooms of the society floors will be large enough for the holding of small professional meetings when occasion may require.

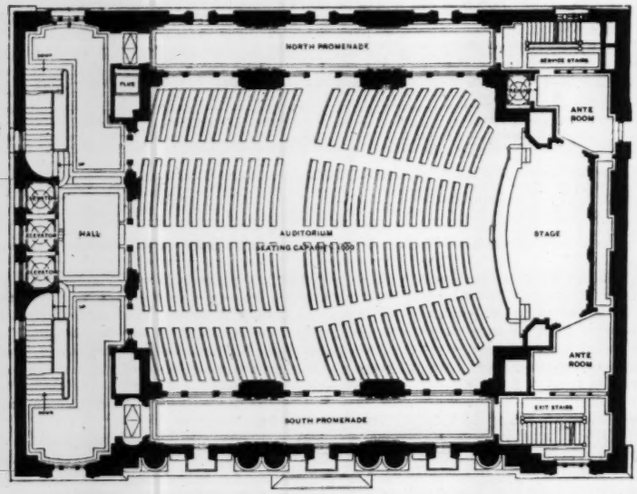
3. A crowning detail, in the planning of the building, has been the provision on the two upper floors for the libraries of the various societies. It is the purpose of the societies so to administer the library of each that by bringing them together there shall be created a working and reference library of the highest possible value and completeness as respects engineering science and practice, which shall be unequaled anywhere. The societies have recognized that there is before them an unexampled opportunity, and it is their desire to avail of it to the highest degree. In seeking this end the entire top floor is to be devoted to reading and reference rooms, to working alcoves, to rooms for photographic reproduction, and for drawing and similar library work. The roof will be specially constructed to secure the best illumination. The location of the reading rooms at the top of the building will be quiet, cool, airy and free from dust. The floor below the library reading rooms will be devoted to the book stacks, although when first the societies enter the building the alcove construction in the reading and reference rooms will take care of the nucleus of the future library which the societies will bring with them. This will leave the book stack floor for growth, as the library shall increase in size hereafter. It is believed that, by the cooperation of the New York Public Library on the adjoining block, and with the interest and strength which the societies will furnish, the library in the Engineering Building can be made the most important engineering library of the country. The committee has tried to provide ample space to acomplish this end.

4. The building is also to furnish office accommodation for a large and continually increasing number of

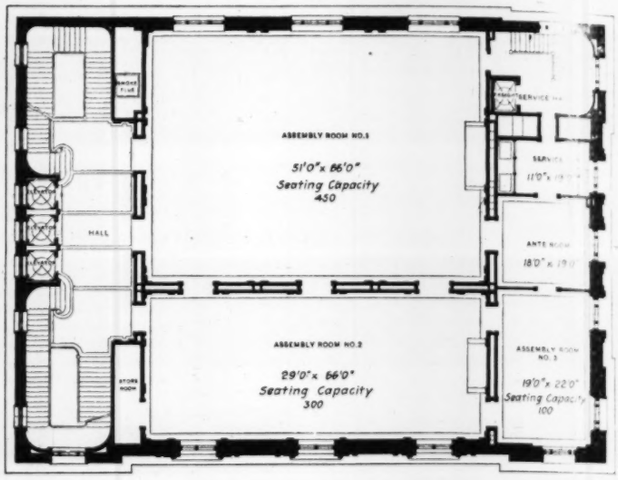
societies which have engineering or some other department of science as their principal object; such are, for example, The New York Electrical Society, The Society of Naval Architects and Marine Engineers, The Heating and Ventilating Engineers, The American Gas Light Association, The National Electric Light Association, The Society of Chemical Engineers, The Association of Edison Illuminating Companies, and many others. For these organizations the building will offer office areas of varying sizes, whose arrangements will be adjusted to the

the third floor. The westerly wall is built 10 ft. within the property line, so that openings for light and air should always be left on that side and on the rear, even if high buildings should be hereafter built on adjoining property to the west and the north. The committee contemplates finishing the building on all four sides and not merely on the south facade, in order that its monumental character may be seen and recognized from every point of view.

It may be serviceable to remind members of details



PLAN OF MAIN AUDITORIUM; THIRD FLOOR OF ENGINEERING BUILDING.

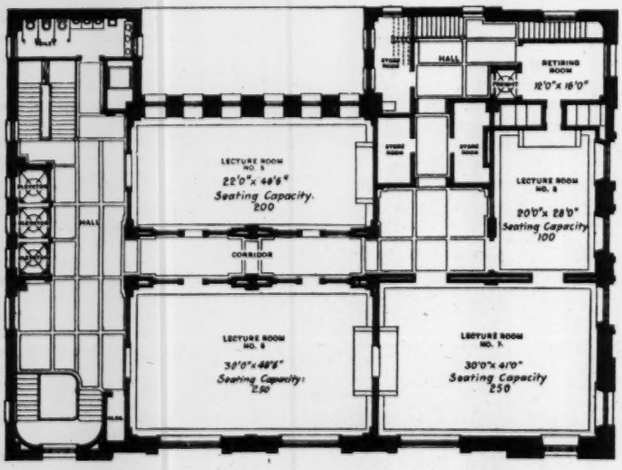


PLAN OF ASSEMBLY ROOMS.

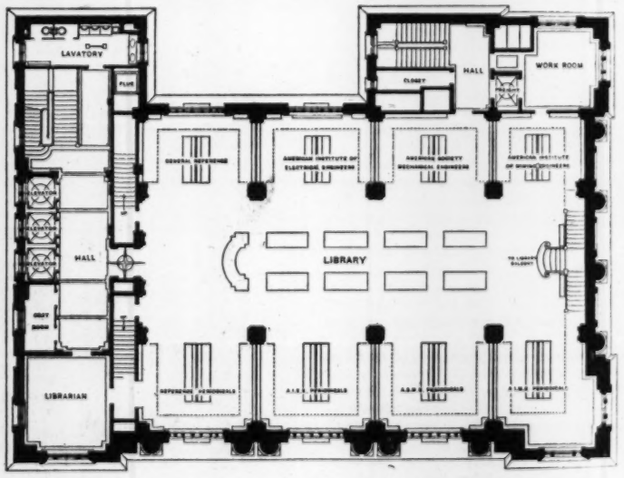
requirements of such participants as shall hereafter be made known. Such participants will have use of the auditoriums of the desired size.

5. The building must also serve as a business office for the Founder Societies and the Associate Societies. A driveway gives access on the street level and under cover to the freight elevator, both for boxes of books and for other merchandise moving inward and for mail-sacks moving outward. This driveway also serves for carriage access to the auditorium and passenger elevators. It gives facility for unloading by gravity to the coal pockets of the heating plant without handling. The general convenience of the building is also served by the receiving and shipping office at the rear on the first floor, through which all goods in and out will be handled.

which have been presented at various times concerning the organization of the holding corporation which is to administer the building for the Founder and Associate Societies. This corporation was formed by special charter in the State of New York, in May, 1904, and is called "United Engineering Society." Its nine trustees are chosen, three each, by the Councils of the Electrical, Mechanical and Mining Engineers, and control the building and are responsible for its financial administration. Its charter and by-laws have been the occasion of much careful thought by the societies and by legal counsel, and the title to the land rests in this body corporate. The land passed to these trustees in January, and they are paying the interest and other expenses during construction. It is the unusual character of the trust and



PLAN OF LECTURE HALLS; SIXTH FLOOR OF ENGINEERING BUILDING.



PLAN OF LIBRARY; THIRTEENTH FLOOR OF ENGINEERING BUILDING.

There is also a Bureau of Information, at the right of the mains entrance, where general questions can be answered, visitors directed, and some routine business transacted. This office will also be a suitable location for the telephone exchange, the telegraph and the sub-post-office.

By a business arrangement formed under legal advice and forming part of the deed to the property to the east of the building, a restriction has been placed which prevents the erection on that lot of a building more than 60 ft. high. This restriction runs with the land and secures light and air for the building on its eastern front above

its functions which are largely responsible for the delay in beginning construction.

The contract for construction was signed in July, the excavation for the foundations was started at once, and the work of construction has now commenced. The contract limit is fifteen months to date of expected completion.

Chas. F Scott, Bion J. Arnold, S. S. Wheeler, American Institute Electrical Engineers; C. W. Hunt, James M. Dodge, F. R. Hutton, American Society Mechanical Engineers; A. R. Ledoux, Chas. Kirchhoff, Theodore Dwight, American Institute Mining Engineers.

A SUMMARY OF PANAMA CANAL PLA[illegible] AND ARGUMENTS.

PART III.

By Wm. Ham. Hall, M. Am. Soc [illegible]

(In Part I. Mr. Hall traced the de[illegible]ment of Panama Canal engineering conflicts. Part II. he reviewed and commented upo[illegible]veral Panama Canal construction projects. In [illegible]pres-ent letter he summarizes the important counts made in the two former parts, together with several additional points, and develops more fully their bearing on the practical problem of selecting a plan.—Ed.)

A Review: From the Sea-Level, Upwards.

The reader of the former parts of these papers will probably have seen:

1. That, for the Isthmus of Panama, a mean sea-level canal would be, in a sense, down "in a hole," and that no reasons have yet been given which are convincing to the conclusion that the additional money necessary to put it there should be expended by the American people, at this time.

2. That a Panama Canal cannot, within practicable cost in money and time, be built, maintained and operated without the handicap, on size of ships using it, due to a lock (the necessary tidal lock on the Pacific side), and that half a dozen locks, all being made the same size, would be no more a handicap to commerce, through restricting ship dimensions, than one would be.

3. That a canal, with a lock at each end, instead of at one end only, and having a water surface at Panama, high tide level, in place of at mean sea-level, can probably be built for materially less money, than the mean-sea-level canal, and the fact of its having two

locks in lieu of one would not render it materially more of a handicap on commerce.

4. The canal having two locks, but with their lifts fixed at 30 to 40 ft., can be built for less money and in less time than one with the two locks and the lift to high tide level, only, and that the additional time taken by ships to the 30 to 40-ft. plane would be insignificant.

In these four propositions are seen what must, at this distance and with the data at our disposal, appear to us the points of weakness of the mean-sea-level general idea for the Panama Canal. Albeit, the proposed application of it has other weaknesses, which, under the circumstances, we must consider.

UNCERTAINTIES AS TO COST.—Aside from the fact that this argument has not been adduced to uphold the claims of practical superiority for a mean-sea-level Panama Canal, and apart from the further fact that it would seem to require, on the estimates already made, about $36,000,000 more than a 30-ft. level one, without having any material advantage over the latter, it would have, both in construction and in maintenance, great comparative disadvantages, and these I have as yet scarcely hinted at. Let us look for a moment at some of them.

A mean-sea-level canal of the dimensions of waterway contemplated under the American plannings would involve the excavation of more than 60,000,000 cu. yds. of material below the plane intended for its water surface, of which 12,000,000 or more cu. yds. are probably "rock," or hard, indurated clay, which will have to be blasted. All of this will probably have to be worked out from under water, except it may be that the great cut from Obispo to Pedro Miguel or Miraflores, can, to some extent, be kept unwatered, while the work is in progress. But to what extent this can be counted upon in a climate of torrential rains and a material of volcanic formation, with the Chagres River and other streams "overhead," so to speak, is and must until tried remain uncertain.

THE BELOW-SEA-LEVEL WORK—ROCK.—All of the material in the below-sea-level prism of the great backbone cut, as well as much of that within the same prism elsewhere along the work, is expected to be "rock." Excavation of such material from under water, the Isthmian Canal Commission estimated at $4.75 per cu. yd., while for the removal of soft rock above water the figure was 80 cts., and for hard rock, $1.15. Contemplate a moment the difference; $4.75 is more than four times the $1.15 or about six times 80 cts. An uncertainty, therefore, will be as to the amount of material to be excavated below water plane which will cost from four to six times the normal rates above it. With the possibilities ranging from somewhere between 10 to 20 million cu. yds., it must be admitted that there is a lot of room for money cost exceeding the estimates on this item. Not leaving this one point of uncertainty as to amount of underwater rock excavation which will have to be handled, the unanticipated money cost which this part of the work might entail, might be as nothing to the delay in time consequent upon it. The blasting and removal of rock under water is one of the most stubbornly slow processes which the engineer is called upon to conduct.

But this point is only the commencement of the special uncertainties attendant upon construction of a sea-level Panama Canal. The dredgeable material from below water was estimated at 20 cts. per cu. yd. That estimated as dredgeable which turns out to be not so—that which will have to be blasted and then scooped or bucketted out—will be "rock," and will cost about the $4.75 per cu. yd., or about 24 times the 20 cts. Now it is expected that rock will be encountered under dredgeable material in a number of places, and some allowance has been made therefor in the estimates. But this item of cost of the under-water part of the work will largely remain, both as to measure of quantity and as to resistant quality, undetermined until the canal shall have been built.

But it is not alone as to how much material will have to be removed at approximately $4.75, and how much at 20 cts., that we would have to eat this pudding before we could prove whether it were good or bad. There is nothing which so knocks out machinery, dredging in soft material and demoralizes the whole work as an under stratum of hard rock encountered here and there. Another chance to drop a large "wad" as well as several years not counted upon.

THE BELOW-SEA-LEVEL WORK—GRAVELS AND SANDS.—But, again, there is yet more uncertainty in this connection. Who knows how those soft gravels and sands, and, possibly, quicksands, lying in the middle Chagres River gorge, are going to behave when dredged through to a plane 35 ft. below sea level? They have been described by the Isthmian Canal Commission of 1899-91, as veritable terrors on which to found a Bohio dam. The Engineering Committee of the first Panama Canal Construction Commission, in February of this year, gave them an equally bad reputation as dam substrata, in the realization of any lock canal project. But they complacently expect them to "stand pat" under water, around an excavated dug out canal cross section, having side slopes of 1 on 2 or 3. The chances are that there will be disappointment in this—that large volumes of such materials, over and above those in the originally excavated sections, will come into the waterway and have to be removed by dredging. The character ascribed to them by the reports I have reviewed in former parts of my communication seems to justify such anticipation. More cost and more time. Greater expense and special inconvenience in maintenance.

THE BELOW-SEA-LEVEL WORK—RETAINING WALLS.—The Isthmian Canal Commission of 1899-1901 considered that so much of their planned waterway as was flanked by the excavated mountain slopes, about six miles, should be walled up on each side, for the treble purpose of holding the slope, receiving the wave wash, and retaining a level berm for railway purposes on each side of the water. Doubtless this was sound. Such retaining walls would be decidedly more necessary in the case of a sea-level canal. Supposedly, they have been provided for in the plannings and estimates of the late Chief Engineer, but the Engineering Committee which reported upon those plans did not go into these details, so we do not know definitely. The reasons which called for retaining walls flanking six miles of the waterway in the summit cut for a 90-ft. water plane canal, would make them necessary, apparently, for some miles greater length of the cutting for a sea-level canal. If, in addition to the above, the before anticipated slip, creep or wash of the gravel and sand sides of the cutting through the middle Chagres division of the work is to be prevented by retaining walls, the total length of such construction necessary would appear to be about 14 miles—from Bohio to Miraflores. Whatever this length may be, however, the present point is that the construction will be almost wholly below the plane fixed for the water surface of the canal, and to a depth of about 5 ft., or more, greater than the navigation depth itself.

How is this work to be put in? Miles on miles of concrete wall at the foot of slopes more or less unstable, and with foundations 40 ft. or more below sea level, must be built. I am not doubting ability to do it. It is entirely feasible. I am calling attention to the construction as another item of uncertain cost in money and in time.

Consider the possible cost and uncertainty of keeping that 14 miles of below-sea-level cutting unwatered, if the attempt be made to do this, so as to cheapen excavation and wall building. Consider the possible additional uncertainty and cost of keeping the wall foundation pits unwatered at the foot of such slopes, through such materials, in such a climate.

Or, if this excavation and wall building is to be handled under water, consider the enormous volume of rock to be "shot" below water, scooped therefrom and carried away, and consider the length of cofferdam or of caisson work which would have to be organized, and operated without mishaps if it is to be safely estimated beforehand. An experienced contracting firm would leave a very large margin for safety in estimating a price to bid for that work. Will an engineer estimating for the Government be justified in doing otherwise? Can his estimate results in any event be depended upon for the purposes of this Government?

UNCERTAINTIES AS TO SAFETY.—If the reader does not picture to himself on the above showing enough of uncertainty in outcome to "give us pause" and prompt us to "accept the ills we have" above sea level in this Panama Canal matter, rather than "fly to others we know not of" below that plane, consider the significance of the available description of the Culebra Cut materials. Mr. George P. Morison's words are:

> While in the upper part of the cut, where the work was first opened, there is some soft and slippery clay, nearly the whole of this excavation must be made through a material which has generally been rated as rock. It is, in fact, an indurated clay, not firm enough to be classed as shale, but perhaps quite as hard to work. It is intersected here and there by thin strata and dykes of hard limestone. It is a material which would weather rapidly and go to pieces in a Northern climate where there is frost; in the damp warm climate of the Isthmus it does better, but when fragments are immersed in water, they fall into powder, and it would evidently be unsafe to expose the unprotected sides of this excavation to the wash of the water in the canal. (Trans. Am. Soc. C. E., Vol. L., p. 170.)

This description was given by Mr. Morison in explaining the necessity for the retaining walls above adverted to. But, if "it would evidently be unsafe to expose the unprotected sides of this excavation to the wash of the water in the canal," how much safer can we assume it to be to leave them exposed on the projected side slopes of 1 to 1, all the way above canal bank to mountain top—100, 200, 300 ft. above us—and under the influence of 80 to 100 ins. of rainfall per year, coming in tremendous downpours within short spaces of time?

My dear Senator, I am no pessimist on the Panama Canal project. I am a friend to it. But I have had a tropical country engineering experience, which happens to be just in point on this subject—the stability of cut slopes in a volcanic formation, now appearing as undurated, seamed clay, under excessive rainfalls; and I tell you that the true friend of the Panama Canal will not knowingly plan for more of such exposed slopes than are absolutely necessary. The deeper the cut is made the more slope is exposed. The danger from it increases in greater ratio than its height increases.

If, by that great cutting through such a formation, inclined seams or dykes on which immense slides will occur under such excessive rainfall influence are not developed, we may consider the outcome as a colossal good fortune. There is a possibility of such mountain-side movement under those conditions as would come near to defeating the whole work within limits of bearable cost.

I do not say such a thing is probable, but it is possible. Every foot deeper you go with that cutting adds to the danger of slashing across the base of inclined seams or dykes and leaves above you greater weight of material and greater area to receive rainfall to start the slip.

It is reasonable to assume that the 40 ft. of additional cutting necessary to put a canal water plane at mean tide level, would more greatly endanger the construction from the causes described than the 80 ft. of cutting next above it.

There has been a lot of talk on the point above, made against the whole Panama Canal project. I make it solely in the interest of business prudence in selecting a plan to carry out that project. From all the foregoing argument it would seem that the bottom of the canal in its summit level should be kept above ocean water plane.

UNCERTAINTIES WITHIN SEA-LEVEL TERMINAL DIVISIONS.—But, returning to below-sea-level causes for uncertainty, we have thus far thought of them only as present through that part of the work recommended to be above sea-level by the Isthmian Canal Commission of 1899-1901, from Bohio to Miraflores.

What I have said, therefore, is applicable only to the final project of the Engineering Committee. But from La Boca to Miraflores and from Boca Mindi to Bohio the 90-ft. summit level project is also planned to be at sea level. Allowing for the 10-ft. low tide drop in the Pacific the canal waterway would have to be excavated to 45 ft. below mean sea to get a minimum 35-ft navigable depth, at the Pacific end. The 8.6 miles from Miraflores to the 6 fathom line in Panama Bay, all through very low ground, involves in the neighborhood of 7,000,000 cu. yds. of excavation, practically all below water, of which about 1,400,000 cu. yds. are rock, underlying the soft mud and sand. 5.50 miles of this division are through the swamps within the mouth (Boca), where, as I have before pointed out, a dam possibly may be constructed to make a navigable terminal lake over the swamp, in lieu of cutting a canal down into and through it.

The advisability of this seems to be further indicated by the fact that it has been authoritatively proposed to construct the canal at less than full depth through this division, to save the cost of blasting and dredging rock from under water, until such time as commerce might demand the full depth of all stages of tide. If this course were adopted, large vessels would have to await high tide in order to get over the shallow. A lock detains a vessel half an hour. To avoid detentions of six hours, more or less, for the largest vessels (battleships, for instance) at this Panama swamp division, on the sea-level plan, some millions of dollars extra will have to be spent in rock excavation at depths as great as 35 ft. at low, 45 ft. at mean, or 55 ft. at high tide. I am not condemning this proposal, I am pointing out that it ought to be proven to be the best and most advisable before it is made part of a plan. A similar word of caution might be applied to the tide level proposition at the Atlantic end. No one knows just how much rock will be encountered under the mud and sands there.

Does it not, on these grounds, look as though prudence prompts the raising of the canal by a one-lock lift, not only through the great cutting and Middle Chagres Valley, but for as much of its length as possible, namely, from Boca Mindi to La Boca—from the edge of the Atlantic to the margin of the Pacific?

THE FLOOD DISPOSAL COMPLICATIONS.—But when we canvass the point further this apparent advisability calls to itself still other support. The Chagres River comes to the canal line at Obispo with a bottom elevation of about 40 ft., and a flood plane level of 60 to 65 ft. If the canal water plane be placed at mean sea level all water permitted to come to it from the upper Chagres would have to be dropped the 40 to 65 ft. The Engineering Committee seems to consider that it should provide for currently passing, at time of flood flow, at least 15,000 cu. ft. of water per second out of its projected Gamboa reservoir. A large basin would have to here be built to receive this water. At best, the construction of such a basin would be fraught with difficulty and uncertainty as to cost. Think of what might be the effect of floods coming into it, inopportunely, during course of building. Think of the duty it would have to perform after it was done.

THE MOUNTAIN TUNNEL SPILLWAY IDEA.—It would seem that the late Chief Engineer had a vivid conception of the advisability of avoiding this drop. We find that he had surveys made for tunnels through mountain ridges, to the length of 3.4 miles in one case and a much greater length in another case, whereby to divert the upper Chagres floods wholly away from the canal. If we could be at all sure of the feasibility and the cost of this tunnel project we might cease consideration of the drop. But who can tell with positiveness what such a tunnel would cost, in such a climate, and in a formation not theretofore explored by tunnel? In the absence of some refrigerating plant to cool the air sent to the headings in that tunneling work, the temperature would be unbearable there. The uncertainties of cost of this proposed tunnel spill-way would exceed the uncertainties attending the below-water excavation for the sea-level canal.

But what can be said of the certainties as to efficiency and safety of such a tunnel after it should be completed. The Engineering Committee say:

If such a tunnel were built at the elevation named, with a diameter of 30 ft., it could be depended upon to discharge 15,000 cu. ft. per second, with the elevation of water surface at 180 to 185 ft., the mean velocity of water through the tunnel being about 20 ft. per second.

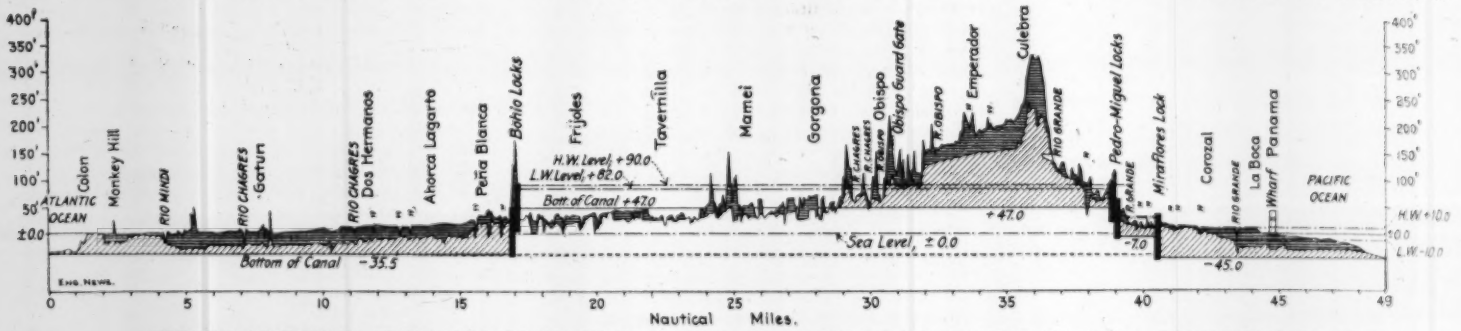
I do not review the calculations involved in this determination. The main point is as to the effect of the claimed result. If that tunnel be not lined and is through material which would withstand the wearing effect of any such velocity, its interior surface would be so rough, with points and ridges and hollows of rock, that the mean rate of 20 ft. of motion per second would not be attained. The bitterly disappointing experience at what is known as Big Bend on Feather River in this State, in attempting to put a large volume of water through a rock cut tunnel with a carefully calculated section, should be studied by any one who wants to mature a judgment as to what can be done on the Isthmus of Panama in that way. If the material is of a kind such as could be excavated and trimmed through to a sufficiently smooth or even plane to admit of the capacity being safely calculated, it would, if not lined, wash out under the influence of such a water volume and mean water velocity. If lined otherwise than in a very expensive manner it would be subject to rapid wear under such stress as 15,000 cu. ft. per second, at a 20 ft. velocity, would put upon it. In any event, the uncertainties of cost, of capacity and of maintenance of such a work, would be so great that if possible it should be avoided.

Consideration of this alternative flood disposal scheme, was evidently suggested by projecting the waterway at Obispo below the level of the Chagres River junction with it. The lower in elevation the canal at this point the more difficulty will there be in dropping the flood volumes to its level, and conversely the greater will be the excuse for considering a tunnel relief proposition.

THE LEAST OBJECTIONABLE ALTERNATIVES.—But, if for other reasons we should reject the sea-level proposal and contemplate raising the canal plane, say, to the elevation of a one-lock-lift, we would have to compare the tunnel escape-way proposition with one to drop the waters between Gamboa and Obispo from about 60 to 30 ft. of elevation. This drop would not be nearly so unmanageable as the 60-ft. fall first spoken of. It might be broken up, within the available half-a-mile, into a series of cascades. But, if retained as a fall and located near the canal, cross currents tending to inconvenience navigation, probably would be engendered. Locating it up the river nearer to Gamboa would, of course, necessitate excavating a channel to it. Whereas, if the canal plane was adjusted to a two-lock lift, the upper Chagres would enter it without drop whatever. The regulated flood flow could be divided, and part be led towards the Pacific and part towards the Atlantic. This would minimize current influence in the navigable waterway and leave only part of the upper Chagres waters to be dropped over an artificially cut spill-way towards the Pacific, while the other part would be taken care of towards the Atlantic by the Gigante Spillway.

ONE-LOCK-LIFT OR TWO-LOCK-LIFT.—Beyond this point in the argument consideration of the Gamboa-Obispo drop involves comparison of a 30-ft. one-lock-lift canal with a 60-ft. two-lock-lift canal. What advantage has the former over the latter? Economy in cost of the whole work? No. If the water plane at Obispo were at 55 to 65 ft. elevation, so that the 15,000 second-feet allowed to pass the Gamboa dam could be received directly into it, the canal would cost about $16,000,000 less than if it was at the 30-ft. plane and there had to be the drop spoken of. Greater efficiency of the resulting work? Apparently not. A two-lock-lift canal would detain ship in lockage only an hour more than the one-lock-lift canal. And enlargement of the water section itself, accomplished with part of the money saved by keeping the summit level at about 60 rather than placing it at about 30 ft., would enable vessels, in the greater speed attainable, to save much of, if not all the time taken for the extra lockage.

But I have now brought this line of argument to a point where my tentative conclusions are not so surely founded. Starting with the sea-level proposition, we have come to a point where the differences in merits and demerits of plans, as based on bottom facts and broad leading arguments, are not so great, and here it will be well to pause and see how nearly we arrive at the same point in coming back from consideration of the highest level proposition. In doing so, however, remember this fact, that the process I have followed has rested mainly on considerations of prudence.



PROFILE OF PANAMA CANAL WITH 85-FT. SUMMIT LEVEL AS PLANNED BY THE ISTHMIAN CANAL COMMISSION OF 1901.
(Horizontal Shading indicates portion already excavated; Diagonal Shading shows excavation still to be done.

A Review: From 90-Ft. Level, Downwards.

The highest lock-canal proposition worthy of note was that for the Panama Canal Company's Technical Committee for a 97.5 ft. summit plane to be supplied with water by a feeder canal from the river just below Alhajuela. This was an extreme, forced by considerations of economy in money and time which we do not have to heed. The same engineers really favored a 66-ft. summit level. Then came the Isthmian Canal Commission proposal for a 90-ft. summit level fixed by a dam at Bohio. This naturally forms our second extreme starting point.

THE DIFFERENCE BETWEEN LOCK-CANAL PROPOSALS.—In their report the Commission say:

The plan recommended by the Commission is, in its general outlines, the same as the second plan recommended by the French Engineers, the one preferred by them, except for the time required for construction.

This is difficult to accept. If the Commission's plan —a 90-ft. Bohio Lake and no Upper Chagres storage— is not to be regarded as distinctly a different plan from the 66-ft. Bohio Lake coupled with the Upper Chagres Alhajuela reservoir, of the French engineers, not to mention a number of other differences which I have adverted to in the former parts, then we may as well stop consideration of the matter altogether. These two plans are about as different as any two-lock canal propositions can be.

But the Commission's report proceeds to show the claimed advantages of its plan over that of the French Engineers, from which it started out by saying it did not materially differ.

The increase in the depth and area of Lake Bohio renders it possible to receive the full flood discharge of the Chagres directly into it without hindering navigation.

Is that in itself an advantage? As a matter of fact, would it not be an advantage, for the sake of the waterway, if all the flood waters could be kept out if it? The making of the 90-ft. Bohio lake as sole storage and sole flood regulator is in itself a distinct disadvantage to the navigable way because of the fluctuation of surface consequent and for other reasons presently given.

THE AVAILABILITY OF THE GIGANTE SPILLWAY.—But the Commission claim for it these collateral advantages: that it enables them (1) "to take full advantage of favorable topographic features of the country in the subsequent discharge of the surplus waters"—this means the Gigante spillway—and (2) "the A[illegible] dam becomes unnecessary for flood control and [illegible] struction may be deferred until additional storage capacity is required, as the result of a large increase in traffic of the canal in the future."

Now, as to the Gigante spillway: While it was not incorporated as part of the record plans, as I understand of the French Engineers, the site for it was discovered and its value fully recognized by them some time before those plans were outlined, but before our Isthmian Canal Commission made its examination and plans. The Commission's own description of the spillway tells:

There is good rock foundation at or above tide level for the entire length of this spillway. It consists of a dam entirely of concrete with a crest at elevation [illegible] ft., terminating in an apron at elevation 65, with a solid foundation below that level.

This seems to show that a spillway can be constructed there as well for the 66-ft. Bohio lake as for the 90-ft. one. Hence, this spillway site cannot be claimed as an advantage singular to the Commission's 90-ft. lake plan, or one not equally open to be used, in, we will say, a 50 to 66-ft. Bohio lake plan.

THE ADVANTAGE IN THE ALHAJUELA RESERVOIR.—But we are given to know that an advantage is secured in doing away with the Alhajuela reservoir. Just what advantage is not said. It certainly is not an advantage on the score of safety. That Alhajuela dam was to be of masonry, on a firm rock foundation, unquestioned as a safe feature in itself; and it was to perform the function of keeping a very large part of the flood waters of the Upper Chagres in a separate basin until they could be doled out as required to the 66-ft. Bohio lake waterway, to replace evaporative loss and lock use, and this was an arrangement good for safety, as for other ends mentioned.

UNSOUNDNESS OF THE 90-FT. SUMMIT PLAN.—But it is not as to these points wherein the 90-ft. Bohio lake project appears to be most unsound as an engineering plan. Observe: the waters are expected to fluctuate 8 ft. To secure the 35 ft. navigable depth at all water stages the walled channel for six miles through the deep cut will have to be 8 ft. deeper or the walls will have to be 8 ft. higher than would be necessary if the water surface were kept at one elevation. Now, this condition is secured by building a dam of immense proportions on a bad foundation at great expense and extreme risk; and that dam, also, must be 8 ft. higher than if the water were held steadily at the low-water plane of the lake. Besides this, the Gigante spillway, a masonry or concrete structure of immense proportions is also run high into air to hold up this fluctuating 82-90 ft. water surface lake; and all for what? Because of alleged "simplicity" and some other implied advantages which do not exist, and because, quoting the Commission's finally claimed advantage for their plan, "A great reduction also results in the amount of excavation required to cut through the continental divide. There is a material reduction of cost." But what the reduction in material or in cost actually is we are not told.

BEARING OF THE GIGANTE SPILLWAY FEATURE.—The Bohio Lake 8-ft. surface fluctuation may be urged as necessary in connection with an open spillway. But by the Commission's figures the crest of the Gigante spillway is planned at 85 ft., while the lake low-water plane is fixed at 82 ft. Here appears to be a clear economic loss of 3 ft. It would seem that, to save the cost of the Alhajuela dam, which would supply water to keep the surface steadily at the level of the spillway lip, the summit cut was planned that 3 ft. deeper and an equal depth was added to the retaining walls; or, looking at it another way, the Alhajuela dam saving is bought at the expense of raising the Bohio dam and locks 3 ft. higher than would be necessary if the Alhajuela reservoir would be provided. It, of course, would require figuring on exact data to show comparisons of cost illustrating the above; but, the one-lake plan seems to be so unsound on general principles, on this score, that it would have to show a very ma-

terial saving in cost to justify its adoption. A lot of objections to the consequences of it would have to be overcome by the money consideration. Some of these are the additional and unnecessary pressure on the Bohio dam foundation, already a vulnerable and dangerous point; the additional and unnecessary height to the big cut retaining walls, already features liable to disaster; the additional and unnecessary height to the Gigante Spillway, in any event a colossal structure over which a vast volume of water will have to be dropped; and the additional and unnecessary height of lock lift, already, in the case of the 90-ft. summit plan, considered excessive by many specially competent engineers. Then, too, the mere additional and unnecessary 3 ft. of water fluctuation is in itself decidedly objectionable for several reasons, which should be apparent and which I do not stop to specify. The main point is that, if by an Upper Chagres storage reservoir the amount of water were opportunely supplied (as it could be) which is represented by the prism between the 82 and 85 ft. plane in the Bohio lake, which amount the Commission allows for seasonal loss and use, then the lips of the spillway might be fixed at 82 ft., and the surface of the water be held there throughout the dry season, with all the advantages I name for the arrangement.

ADVANTAGES OF ALHAJUELA RESERVOIR.—Thus it seems that an Alhajuela reservoir in connection with the Isthmian Canal Commission's Bohio lake plan would effect a number of important betterments to it. It would lower and cheapen its dam and reduce pressure on the questionable foundation thereof; it would lower and cheapen its Gigante spillway and diminish stress due to the water overflow; it would lower and cheapen the locks and diminish lock lift now gravely questioned; it would lower and cheapen 12 miles of immense retaining walls in the great cut and correspondingly reduce danger of disaster overtaking them; it would reduce the fluctuations of the lake's surface and render its margins less unsanitary, and make it a better navigation-way. Moreover, it would distribute volumes and risks, which is always a desirable thing in this class of hydraulic engineering.

MODIFICATION OF THE COMMISSION'S PLAN.—Broadly, the 90-ft. summit work, it would seem, might be made an 87-ft. summit work by coupling the Alhajuela reservoir with it, to very great advantage, and, as far as we know, without materially greater cost; for, observe, the great cut would not have to be made any deeper, and the saving on Bohio dam, Bohio locks, Gigante spillway, and great cut retaining walls would go towards meeting the cost of the Alhajuela dam, etc. But even this arrangement could be bettered by placing automatic operating shutters on the crest of the Gigante spillway so as to waste water, when necessary, at the 79-ft. plane but still hold the low water surface at 82 ft. Thus we might, economically speaking, gain another 3 ft., to advantage, all along the line, as above, and to the special advantage of making extreme lock lift at Bohio 42 ft. for each lock, in place of 45 ft.

But, if the above changes were made, the plan would be a different one, and would, in truth, be like that of the French engineers, except in having an 84-ft. in place of a 66-ft. summit level.

SOME CLOSING COMPARISONS.

And now my argument has brought us to a point where the remaining question is as between a 60 to 66-ft. summit plan like that of the French Engineers, and an 84-ft. summit plan similar to theirs. We came up to the first plane and came down to the second. Here again the relative merits of the plans are not readily determinable on broad grounds or basic argument alone. We must appeal to structural details and to consequent risks or uncertainties; and, finally, to relative costs in money or in time.

It may be conceded at once that an 84-ft. summit canal on the lines above laid down would cost about $150,000,000, or about $25,000,000 less than a similar 66-ft. summit work. It would probably take from one to two years longer to build the lower and more expensive than the higher and cheaper work.

The objections to the higher level are found principally in the greater dangers, risks and uncertainties consequent upon the higher Bohio dam and locks, and greater lock-lifts and greater height of Gigante overfall. Another disadvantage might be that a Gamboa Upper Chagres reservoir cannot so readily or to so great relative advantage be made a part of it, as it could in the case of the 66-ft. summit plan.

If, as the Engineering Committee declared is the fact, a Gamboa reservoir dam is entirely feasible, there would be much advantage in having the Upper Chagres storage and regulator work located at that site, rather than at Alhajuela. It would stop all upper Chagres flood waters from being precipitated into the canal; the Alhajuela regulator would hold up only a part of them.

Probably, taking into consideration the more convenient locality and the cheaper form of dam possible for the site, the larger Gamboa reservoir could be made at not materially greater cost than the Alhajuela reservoir. If that be the fact, the Bohio lake fluctuation could be still more reduced, with benefit all along the line hereinbefore traversed.

The preponderating influence of these considerations seems to lean decidedly towards the lower summit level work of the two we are now considering. And just here, of course, the results of exact and comparable estimates would serve not only to check up my reasoning, but would show just what sacrifice would have to be made in money and time to avoid the risks and disadvantages of the higher level work and secure the advantages and safety of the lower.

Some General Conclusions.

On the basis of the above course of reasoning, "the most practicable and feasible plan" for this Government to adopt in constructing the Panama Canal would seem to be one with a Bohio lake summit level, at about the entirely safe limit of a two-lock lift, one with a not excessive or unnecessary stress upon a Bohio dam foundation, and, at the same time, one in which the Gamboa lake (accepting the Engineering Committee's judgment on this point) can to good advantage be adopted as the upper Chagres regulator. This plan would have a summit elevation somewhere between 60 and 70 ft. above mean sea base. It would be, in its outline, practically the plan of the French Technical Committee, except in the substitution of Gamboa for Alhajuela lake, and the substitution of the Gigante spillway for the two spillways which that Committee's plans provided for near the Bohio dam. This is as near as general reasoning on the published data enables one to come to a conclusion as to the main question. Some other points may be added.

POSSIBILITIES OF ENLARGING CANALS.—A sea-level canal cannot be made deeper without lowering its bottom by excavation. To effect this the walled portion of it must necessarily be built in anticipation of the deepening—the wall foundations would have to be deep enough in the beginning to allow of the subsequent excavation of the waterway and still have their footings far enough below the canal bottom.

A lock-level canal can be readily made deeper, without materially interfering with the traffic upon it, by simply raising its banks and walls and raising and increasing the lift of its locks, and correspondingly raising its water planes.

ADVANTAGES OF THE LARGER CANAL.—Restriction in width and depth of waterway may constitute more of a handicap on commerce by limiting navigation speed than would delays at locks. Hence, a canal at a greater elevation but with a larger waterway may admit of the quicker as well as the safer passage of vessels.

ADVANTAGES OF LAKE WATERWAY.—In all that I have written I have said nothing about the provision of places for vessels passing each other in the waterway; but it is manifest that provision of such passing stations would be more difficult and expensive in a sea-level than in a high-level canal, because of the higher banks and longer slopes to be excavated in widening the channel at the passing stations.

In this connection open lake navigation has a greater advantage as a waterway, and the Bohio lake will be of collateral value on this account. But the 90-ft. Bohio lake would afford but little if any advantage over a 65 to 70-ft. one, for the navigation length above Bohio dam, whatever elevation its surface after surmounting about 60 to 65 ft., would remain nearly the same. The river-bed elevation at Obispo, the head of the lake, is 40 ft. With a 65-ft. water-plane the excavation would only have to be 10 ft. to afford the desired 35-ft. depth, and the width of the valley up to this point seems to be ample to give room for what would be, practically, open lake navigation. The higher water-plane, of course, would mean no excavation at that point, and greater channel cross-section, but if by a small amount of excavation a more than sufficient cross section could be obtained at the lower lake level, the advantage of the higher, on this count, would not be material.

With the suggested terminal lakes included the total possible length of lake navigation would be about as follows:

Atlantic terminal lake:		
Mindi to Bohio	9.5	miles.
Middle Chagres lake:		
Bohio to Obispo	13.9	"
Pacific terminal lake:		
Miraflores to La Boca	4.1	"
Total	27.5	miles.

The advantages possible from terminal lakes have been sufficiently indicated in Part I. My suggestions regarding them have been made only by way of pointing out that such possible features have never been considered on their merits, and that they should not be passed over in silence or disposed of otherwise than upon definite consideration. In my opinion, there need be no delay in construction occasioned by such field examination as would be necessary to obtain data on which to make this determination.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS: FIRST ANNUAL MEETING.

A new technical society of promise, which began its formal existence about a year ago, inaugurated its active life by a two days' meeting in New York City on Dec. 4 and 5. The American Society of Refrigerating Engineers was organized in December, 1904, by a number of New York engineers closely interested in the subjects of ice-making and artificial refrigeration, and elected as President Mr. John E. Starr, of New York, and as Secretary Mr. W. H. Ross, of New York. During the year past the organization was perfected and preparations were made for the presentation and discussion of technical papers at the first annual meeting. The results appear to indicate that the interest in the society's purposes is sufficiently strong and wide-spread to guarantee the society a stable existence and successful progress. Some fifty members were in attendance at last week's meeting, papers to the number of a dozen were presented, and active discussion was had at each of the four technical sessions.

The meeting was held in the rooms of the American Society of Mechanical Engineers, 12 West 31st St., New York City. Three sessions were held on Monday, Dec. 4, and one on the following morning. A banquet Tuesday evening closed the meeting.

Besides the regular election of officers, only one item of business was transacted during the meeting. Repeated reference was made in the technical discussions to the work of the U. S. Department of Agriculture in studying the effect of cold storage upon food stuffs. Up to the present these studies have been conducted solely by means of the facilities available in commercial cold storage warehouses. Temperatures within a certain range have been thus available, but lower temperatures, and varying humidity, cannot be experimented with under present conditions. It is proposed therefore to ask Congress for an appropriation for an experimental cold storage plant. Upon motion of Mr. W. T. Robinson (Philadelphia, Pa.) the society voted to address the Secretary of Agriculture, endorsing this purpose and urging that the appropriation be granted.

The election of officers resulted as follows: President, Mr. W. E. Parsons (New York, N. Y.); Vice-President, Mr. J. E. Starr (New York, N. Y.); Treasurer, Mr. W. C. Reid (New York, N. Y.); Members of Council, Messrs. Louis Block (New York, N. Y.), Edgar Penney (Newburgh, N. Y.), and H. B. Roelker (New York, N. Y.).

The technical proceedings were opened by President J. E. Starr with an address in which he portrayed the large importance of artificial refrigeration in modern life. The dairy, meat-handling and packing industries, brewing and wine-making, all depend vitally on mechanical refrigeration. Cold storage is essential for the preservation of many articles of food. Recently metallurgy has called upon mechanical refrigeration for aid, and the textile and tobacco industries are likely to make use of it in a short time. Civil engineers employ it for help in shaft sinking and tunneling. Its great use for cooling hospitals, meeting halls and the like may also be mentioned.

Following this, President Starr read a paper entitled "Pipe Line Refrigeration," which reviewed in brief the work done in providing public service refrigeration by means of pipe line distribution, and the principal technical characteristics of refrigeration pipe lines, both those using brine circulation and those using direct expansion, and recounted the progress made in solving the various constructive problems presented in the construction and maintenance of such systems. Referring to pipe radiation in the cold brine system Mr. G. T. Voorhees (St. Louis, Mo.) said that some years ago, on the pipe lines of the Quincy Market Cold Storage Co., in Boston, he had attempted to measure the temperature rise on a 1,500-ft. length of pipe, but found no difference that was measurable by ordinary chemical thermometers. There was much discussion on joints for the distribution pipes of such systems. Mr.

V. R. H. Green reported that trials of thermite welding in comparison with Boyle union joints on one distribution system appeared to show that the former was cheaper on ½-in. to 1¼-in. pipe, which covers a large amount of the piping; for larger pipe, however, the expense and trouble of thermite welding make the union joint preferable. Other speakers made note of the wearing out of rubber packings in pipe joints; these seem to take a permanent set after, say, five years, under the continual working due to temperature changes, and then give much trouble from leakage. Rusting of refrigeration pipe lines was somewhat discussed, but no definite data resulted. The Atlantic City (N. J.) system, installed 12 years ago, and exposed to tidal ground waters, gave much less trouble than expected; at several points electrolysis caused concentrated corrosion. The paint question also brought out discussion, but without result except commendation of "Bitumastic Solution" for condensers. The oldest ammonia pipe line, said Mr. Starr in reply to a question, is in St. Louis, Mo., laid in 1889-90; some parts of the original pipe on this line are still in service. One or two brine lines existed before the St. Louis system was installed.

ICE MAKING.

The production of artificial ice was discussed in three papers: "Elements governing the Selection of the Plate System and the Can System," by Mr. Edgar Penney (Newburgh, N. Y.); "The Evaporator for use in Distilled Water Ice Plants," by Mr. Louis Block (New York, N. Y.); and a paper by Mr. Henry Torrance, Jr., of the following formidable title "Does a 100-Ton Ammonia Compression Plate Ice Making Plant or a 100-Ton Absorption Plate Ice Making Plant equal in Economy a 100-ton Plant having a Compression Machine in Combination with an Absorption Machine, using the Exhaust of the Compression Machine for operating the Absorption Machine."

According to Mr. Penney, plate freezing, which acts from one side only, purifies the water of foreign material, and at a slow rate of freezing even of calcium carbonate; can ice contains all the impurities of the water. The plate system produces ice which can be stored like natural ice; can ice disintegrates in storage unless mechanical refrigeration is used in addition. The plate system produces 10½ to 14 lbs. ice per pound of coal, the can system only about 6 lbs. A plate plant will cost 35 to 75% more to install than a can plant. For cooling cars and the like, the can system is by far preferable; where ice should be pure, the plate system is advantageous, as can ice must then be made from distilled water. The plate system can work with water or electric power, while the heat required for distilling makes a can plant for domestic ice dependent upon coal. Mr. Thos. Shipley (York, Pa.), spoke more in favor of the can system, which he would prefer unless electric or water power can be obtained at unusually low cost. He cited averages of first cost as follows: Can system, $550 per ton daily output; block system, $650; plate system, $800; brine-plate system, $1,000. Much discussion arose as to the possibility of avoiding all organic odor in can ice, but an almost hopeless difference of opinion developed, some claiming that it can never be wholly avoided, while others claimed that with reasonably good water and effective filtering it can always be avoided. On the matter of storing plate ice, Mr. J. N. Briggs (Coeymans, N. Y.), stated that the cost of handling in and out of storage is not less than 25 cts. per ton, storage would cost about 20 cts. extra, and a wastage of about 20% additional would be found.

The paper of Mr. Block was a description of the Lillie evaporator, which is single-effect, but heated by exhaust steam. He stated that triple or quadruple effects do not promise any economy over the single effect and therefore have never been built; considering both heating effect and the detrimental effect of increased back pressure on the engine, the single effect is as efficient as a multiple effect. The evaporator adds about 15 to 20% to the cost of a can ice plant.

The argument of Mr. Torrance, comparing a combined compression and absorption plant with a separate compression plant and a separate absorption plant, was a calculation based on average data partly from practice and partly assumed, of the coal consumptions of the three kinds of plant. The results are, roughly,

100-ton compress.on plant.....11.2 tons ice per ton coal
100-ton absorption plant.....14.4 tons ice per ton coal
100-ton combined plant (32-ton compression plant with 68-ton absorption plant) .....17.8 tons ice per ton coal

The whole calculation hinged on the feasibility of using the exhaust steam of the compression plant, at 1-lb. pressure for evaporating in the absorption plant. This brought out decided differences of opinion. Mr. Voorhees, Mr. A. P. Criswell (Detroit, Mich.) and others claimed it to be commercially impracticable, while Mr. Torrance, Mr. Starr and others upheld its feasibility. It appears that several existing absorption plants have been designed to run at 1-lb. steam pressure, but these often (or usually?) work at higher pressures, 4 lbs. to 15 lbs. An explanation of this fact is that the higher pressure requires much less careful operation, and in a separate plant it is hardly less economical than the lower pressure.

REFIGERATING MACHINES.

While the preceding three papers touched the subject of Refrigerating Machinery to some extent, it was more directly dealt with in three other papers, as follows: "The Carbonic Acid Refrigerating Machine," by Mr. J. C. Goosmann (Chicago, Ill.); "The Practical Value of Indicating the Ammonia Compressor," by Mr. W. E. Parsons (New York, N. Y.); and "The Requirements of a Small Refrigerating Machine of Less than 1-ton Capacity," by Mr. M. R. Carpenter. The first-named of these, a very extended discussion of carbon dioxide, its suitability for refrigerating purposes, and some of the essential points of difference between carbonic acid machines and ammonia machines, need not be dwelt on here. The paper of Mr. Parsons, which was substantially a short exposition of how certain irregularities of a compressor may be read out of the indicator card, is of interest chiefly because of the ensuing discussion. Mr. Thos. Shipley (York, Pa.), asserted bluntly that the indicator is of no value whatever as a guide to the action of an ammonia compressor, and that the best guide is a set of thermometers, permanently placed in the suction and the discharge pipes of each cylinder. The thermometers indicate at once, by the drop of discharge temperature, any defective action. Mr. Voorhees spoke in favor of using indicator cards provided the adiabatic compression line be plotted on; in proper working, the compression line follows the adiabatic exactly for three-fourths its length. He remarked further that ammonia gages are exceedingly liable to be wrong, and that a gage-tester should be part of the regular equipment of a refrigeration plant. Mr. Shipley confirmed the view that ammonia gages are very liable to error, and stated that mercury gages should always be fitted to compressors. Reference was made to an experimental plant erected by the York Mfg. Co., York, Pa., on which numerous experiments have been made by a committee of the Ice-Machine Builders' Association. Mr. Shipley offered the use of this plant of the American Society of Refrigerating Engineers for any specific tests it might care to make on ammonia compressors. The offer was accepted with thanks.

The paper of Mr. Carpenter on small refrigerating machines portrayed equally clearly the large field for automatic refrigerating plants in capacities from 200 lbs. to one ton, and the difficulties which beset the construction of such machines. Generally, electric power is the only power to be considered for such plants, though the machines should be so built, preferably, that a gas or oil engine may be used as drive where electric power is not available. The difficulties are, first, the requirement that any unskilled attendance, a house servant for example, may be capable of operating the machine, and, second, the necessity of avoiding great complication, so that in case of derangement it may be possible to use local talent for remedying the trouble.

COLD STORAGE.

Several papers dealing with problems of cold storage were presented. A rather general survey of a large part of the subject was given by Mr. W. T. Robinson (Philadelphia, Pa.) in a paper entitled "Cold Storage Requirements for [illegible]eration of Perishable Products." In [illegible] this paper offered the view that little [illegible]nite knowledge exists on the questions [illegible]ation in storage, influence of temper[illegible]ence of humidity, etc. The work of [illegible]ment of Agriculture in studying th[illegible] promises to be of very great value [illegible] storage industry and to the country [illegible]. Some substances improve, or at least [illegible] in cold storage, while others deterior[illegible] but surely. Most food products abso[illegible] odors or flavors readily, and must th[illegible] stored separately. The increasing dema[illegible] storage has also brought a demand for l[illegible] peratures, which demand is going ev[illegible] To-day, temperatures of 0° F. are asked [illegible] for less money than ten years ago was [illegible] temperatures of 25° and 30° F. Future [illegible] of cold storage warehouses must [illegible] to lower temperatures, by providing [illegible] ough insulation (especially of floors), and must provide more fully than has been done for separation of stored materials. Fireproof construction has not been as thoroughly followed as will have to be done in the future. Insulation becomes more difficult as fireproofing is more thoroughly looked after, but both requirements will need to be fully met.

Mr. Robinson mentioned that a recent novelty in warehouse work is the cure of hay-fever sufferers. An exposure to freezing temperature, with the patient properly dressed and enjoined to keep moving, is effective often after only a few hours. Several successful cures were reported by him, and several other cases of doubtful or partial cure.

Mr. H. M. Haven (Somerville, Mass.) stated that some years ago, in the storage of eggs, it was shown by a combination of experience and experiment that eggs when stored too moist become covered with a fine fungus, which destroys their good taste; and that if the humidity is held down to 80% this growth is prevented. Indirect circulation, using brine coils and calcium chloride, was employed to control the humidity.

Mr. W. C. Reid (New York, N. Y.) read a paper on "Furs and Fabrics in Cold Storage." He referred to the recent origin and slow growth of this branch of the warehousing business, but stated that with good management, given a suitable location to develop a fur storage business, a large and profitable trade can be built up. A temperature of 40° F. is safe, but 35° to 40° is better for the purpose. Careful fireproofing is highly essential in such business, because the stored material is of high value and because the warehouse must insure it against all kinds of loss.

A subject of much interest was discussed by Mr. G. H. Powell of the Department of Agriculture, in a paper entitled "Problems in the Transportation of Perishable Fruits." The fruit industry of this country, a large and growing one, is almost dependent upon refrigerated transportation to reach a suitable market. Under the existing conditions of packing and shipping, the refrigerator car does not cool all of its contents to a temperature safe against further ripening in less than 2 to 10 days, depending upon the kind of fruit, method of picking, temperature of packing, etc. This restricts the market, causes large losses in over-ripening and decay and even so requires picking the fruit green. Progress may be attained by some means for cooling the fruit to a "safe" temperature in, say, one day or less after picking, and then maintaining this temperature by the iced cars. The various phases and restrictions of the problem, possible directions of solution, etc., were cogently discussed by the author. One method of solution which is being tried was mentioned both by the author and by Mr. L. Williams (Boston, Mass.). The United Fruit Co. has built at Springfield, Me., a refrigerating house in which railway cars packed with fruit can be refrigerated before shipment. The house has a capacity of 36 cars, and contains a refrigerating plant with suitable airboxes and ducts by which cold air may be blown into one end of a car and drawn out of the other end. A drop of 26° in 24 hours can be obtained by this plant. Only three months' experience with this plant is yet available, but it promises excellent results. In fact Mr. Williams believes that

of such a plant were provided at intervals of 500 miles or so, cars could be run from one to the next without ice, if cooled down to the danger point at the start and then run wholly closed, with only a crack open in the rear of the roof to let out the heated air. In actual experience on the Springfield plant it has been found that cars, after being refrigerated, can be run 10 hrs. with only 2° to 3° temperature rise.

The other technical proceedings included the discussion of a number of selected topics, a paper on "Engineers' Specifications vs. Contractors' Warranty," by Mr. J. C. Wait (New York, N. Y.), which latter was read by title in the absence of the author. The topical discussion included a miscellaneous variety of subjects. The subject of boiler compounds brought forth several extended contributions, notably by Mr. J. C. Parks (New York, N. Y.) and Mr. A. A. Cary (New York, N. Y.). The question whether ammonia gas is inflammable or not was answered by general opinion in the negative; the question has already been at issue in damage suits, wherein it was decided that it is not inflammable. The gas will, when supplied to a constantly-burning light, cause a large sheaf of flame, which may transmit fire, but it will not support combustion when unaided by another flame.

THOMAS LEIPER PATTERSON.

By John C. Trautwine, Jr.*

Thomas Leiper Patterson, gentleman and civil engineer, died in Cumberland, Md., on Saturday, Dec. 2, after a day's illness with pneumonia. I had not the good fortune to meet Mr. Patterson until a few years ago; but his personal qualities at once endeared him to all who met him. He was a rare type of the veteran civil engineer. In June last he gave me many reminiscences of his life, and to these I am chiefly indebted for what follows.

Mr. Patterson was born in Philadelphia on August 16, 1816, while his parents were temporarily occupying rooms in one of the buildings of the University of Pennsylvania, then on Ninth St., below Market St. His father, Robert Maskell Patterson, was a man of remarkable parts. Mr. Patterson says: "My father was not only an expert mathematician and natural philosopher, but also an excellent botanist. Indeed, I can recall no more accomplished man than he was. I think he must have known the Bible by heart." He was Professor of Mathematics and Natural Science, first at the University of Pennsylvania and afterward at the University of Virginia, at Charlottesville. At twenty-two he was made a member of the American Philosophical Society, the youngest member admitted, up to that time. He afterward became its President. In 1833 he was appointed, by President Andrew Jackson, Director of the Mint.

Mr. Patterson's mother was Helen Hamilton Leiper, daughter of Thomas Leiper, of Scotland, who built what is said to have been "the first permanent tramway in America," connecting his mills, on Crum Creek, below Philadelphia, with tidewater on Ridley Creek, about a mile distant. His engineer, on this work, was the father of J. Edgar Thompson, afterward President of the Pennsylvania Railroad Co.

Mr. Patterson's paternal grandfather, Robert Patterson, seems to have been no less remarkable a man than his son, Mr. Patterson's father. He was born in Ireland in 1743, came to America in 1760, and, like his son, was Professor of Mathematics in the University of Pennsylvania, President of the American Philosophical Society and Director of the Mint, having been appointed to this position by Thomas Jefferson in 1805. And he had the further distinction of being the first Superintendent of the U. S. Coast Survey.

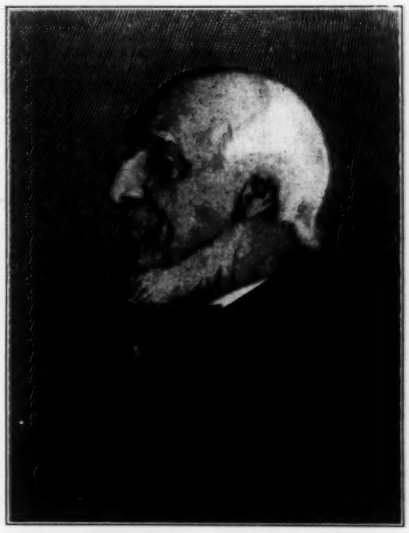
From 1828 to 1835, Mr. T. Leiper Patterson was a student in the University of Virginia, at Charlottesville. In 1835 he came to Philadelphia and took employment under William Strickland, Architect and Engineer, who "was a very remarkable man, clever in every way and especially handy with his pencil. When married, he gave his last five dollar bill to Bishop White."

*Civil Engineer, 257 South Fourth St., Philadelphia, Pa.

At that time, what is now the Philadelphia, Baltimore & Washington Division of the Pennsylvania Railroad was under construction. Strickland Kneass was Chief Engineer of the portion from Philadelphia to Wilmington, William Strickland of the Wilmington & Susquehanna, and Benj. H. Latrobe of the portion between the Susquehanna and Baltimore.

Mr. Patterson was assigned to my father, who was Mr. Strickland's first assistant, and remained on the work until 1837. The severity of the winter 1837-8 compelled a stoppage of operations when (Mr. Patterson says) "it was only with the greatest difficulty that I made my way back to Philadelphia, as the roads were nearly impassable, and traveling accommodations were scarce and very expensive."

In 1837 Mr. Patterson was appointed resident engineer on the construction of the Chesapeake & Ohio Canal, and thus entered upon what proved to be his life work. He says he had scarcely even seen a canal; but Strickland had told him "Remember, young man, there is one quality which the engineer needs above all others, and that is impudence. If there is anything you don't know, never let anybody find it out." Mr. Patterson claimed to have faithfully followed this instruction, and evidently to good purpose, for he afterward became chief engineer of the work, which was completed in 1850. At the time of the Johnstown flood, Mr. Patterson was engineer to the Receivers of the Canal Co., and, in that capacity, although then about 73 years of age, made a horse-back trip from Cumberland to Washington, inspecting the works which had been injured by the flood.



Thomas Leiper Patterson.
(From a photograph taken in April, 1905.)

In 1844 he made a horse-back tour of the West, visiting Michigan City, where his father owned some 36 acres of town lots, then worth about a dollar per acre, and Chicago, out of which it then took him only half an hour to ride.

In 1845 he spent a month upon the Schuylkill Navigation, under Milnor Roberts and Ellwood Morris. About this time he and his father were members of a committee of the Franklin Institute to report upon the condition of the crib dam of the Fairmount water-works, Philadelphia, which had been seized with alarming fits of trembling. A delegation from the City Councils met the committee at the dam, and Mr. Patterson gives an amusing account of the hospitalities provided, which, however, did not prevent him and another gentleman from making their escape from the party and counting the vibrations of the structure, which, he found, were at the rate of 544 per minute.

In 1847 Mr. Patterson married Louisa A. Sprigg, daughter of Michael C. Sprigg, M. C., of Cumberland. Mrs. Patterson died in 1899.

In 1861 Mr. Patterson was in charge of the U. S. Armory at Harper's Ferry, and was engaged in building a dam there across the Potomac River. From 1865 to 1870 he was farming in Maryland.

In 1877 he began the surveys for the location of the George's Creek & Cumberland Railroad, which connects the city of Cumberland with the bituminous coal mines between that town and Lonaconing, some thirty-five miles distant. Henry Loveredge was then president of the road. James A. Millholland, son of James Millholland, of the Reading Railroad, was general manager, and his brother, Henry, was the draftsman.

Mr. Patterson took a lively interest in all that concerned the welfare of the town of his adoption, and especially in its water supply and other engineering features. He made a study of the possibilities of a water supply from Evitt's Creek, by means of which he hoped it might be possible to avoid the use of the Potomac, the water of which was highly polluted, notably by a pulp mill some twenty-eight miles upstream from Cumberland.

Visiting a married daughter at Petersburg, Va., he was deeply impressed with the admirable results there accomplished in the reduction of waste by the use of water meters, and he never relaxed in the vain effort to get his fellow townsmen of Cumberland to see and appreciate the situation there, where the waste is scandalous. Less than two days before his death, he was engaged in tabulating the Petersburg results, evidently underestimating the strength of conservatism and fondly hoping that these figures must penetrate the local brain. Only a year ago, he spent a considerable portion of three days on horse-back, while engaged in surveys in the vicinity of Cumberland.

To the last his mental vigor was that of a highly intelligent man in the prime of life. Just before his death he was planning a trip to Fort Frederick, Md., in the hope of effecting the preservation of the remains of a revolutionary fort at that place.

It would be idle to attempt to describe his personality to those who had not the rare good fortune to meet him. The beauty of his character is admirably shown in the inscription on the tombstone of his son, recently deceased. Here, instead of following custom and inscribing "son of T. Leiper and Louisa A. Patterson," he had graven: "son of Louisa A. Sprigg and Thomas Leiper Patterson."

CEMENT JOINTS FOR GAS MAINS.

Cement joints for gas mains were adopted by the Laclede Gas Light Co., of St. Louis, Mo., in 1904. Subsequently the company was ordered by the Director of Public Works to discontinue the use of cement for joints. The reason given for this order was that the joints would undoubtedly leak in the future, necessitating disturbance of the streets for repairs. The company at once addressed circulars to 60 gas companies asking for their experience with cement joints and the attitude of their respective city authorities on the subject. A total of 52 replies were received. These replies, together with the results of numerous tests of cement joints in St. Louis, tables comparing the cost of cement and lead joints and a general discussion of the subject, were submitted to the convention of the Western Gas Association at Chicago last May, in a paper by Mr Jacob D. von Maur,* C. E.

The points brought out by the circulars sent to the various companies are summarized by Mr. von Maur as follows:

(1) In general, those answers which are unfavorable to the use of cement come from cities where cement has never been tried very extensively.
(2) There seems to be a prejudice against the use of cement in the business sections of the very large cities.
(3) In a number of cases cement joints were used to a very limited extent with very good success, yet for some unexplainable reason its use was not continued.
(4) In every case, with one exception, Portland cement was used and in the exception noted Rosendale cement was used.
(5) There is a difference of opinion as to whether it is necessary to use the foreign or more expensive brands of Portland cement or domestic cements.
(6) There is a very wide difference of opinion as to whether provision should be made for expansion or not.

*Superintendent of the Street Department of the Laclede Gas Light Co., St. Louis, Mo. The paper was a long one. It may be found in full in the "Progressive Age" of June 15, 1905, where it fills about a dozen pages.

but in every case where provision was made at all it was done by inserting lead joints at stated intervals.

(7) It seems to be the generally accepted opinion that cement should not be used in soft places or in any place where there is likely to be a settlement of the pipe or where the pipe is subjected to vibration.

(8) It is very important to note that in almost every case the tests applied to pipe laid with cement joints are many times greater than the tests applied to pipe laid with lead joints.

(9) In only one case was an objection made by the city officials to the use of cement joints and this objection was removed as soon as the value of the cement joint was demonstrated; so that at present we have no record of an objection on the part of the city officials to the use of cement in making up joints.

(10) In no case has the leakage increased by the use of cement, and in nearly every case the leakage has decreased.

Mr. von Maur emphasizes, at another point in his paper, the importance of laying gas pipe on a solid foundation, without which, he says, it is useless to try to prevent leakages. He suggests laying a board or plank beneath each end of each length of pipe, the board being laid flatwise at right angles to the pipe and being embedded to its own depth in the earth. Of course holes are dug for the pipe bells.

Nearly a third of the cities were not using cement at all, but of those a few proposed to do so soon.

The following cities were using cement for all or nearly all joints: Atlanta, Ga.; Bridgeport, Conn.; Camden, N. J. (for all low-pressure mains; do., same company, for Trenton and for numerous small towns); Chester, Pa.; (also coating all wrought iron pipe with cement as a precaution against electrolysis); Danbury, Conn.; Derby, Conn.; Des Moines, Ia.; Fall River, Mass.; Grand Rapids, Mich.; Houston, Tex.; Lowell, Mass.; Mt. Vernon, N. Y.; New Orleans, La.; Paterson, N. J.; Philadelphia, Pa.; Pittsburg, Pa.; Reading, Pa.; St. Augustine, Fla.; Savannah, Ga.; Scranton, Pa.

The report from Chicago stated that a 16-in. main was laid with cement joints in 1862 and, so far as known, has given no trouble from leakage. In a number of cities cement joints have been used for 40 to 50 years.

Tests of cement joints in various sized mains at St. Louis were as a rule very favorable as to tightness.

The approximate saving in using cement instead of lead was given by Mr. von Maur, as shown by the accompanying table, the columns of larger figures being for heavier lead.

Approximate Saving per Mile of Gas Main by Using Cement Instead of Lead Joints.

Diameter, ins.		
4	$170.00	$114.80
6	218.00	129.80
8	319.00	165.00
10	398.00	244.20
12	490.00	337.92
16	660.00	554.40
20	834.00	822.80
24	1,249.00	1,137.08
30	1,632.00	1,485.00

ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The 52d meeting of this society, held Dec. 5 to 8 in New York City, was the most largely attended meeting by far that the society has ever held. Indeed, the number registered in attendance breaks the record for any meeting of a single engineering society in this country, so far as we are aware. The total number of members and guests registered at headquarters was over 1,300, of which we judge over 700 were members of the Society in some grade. The attraction which brought so large an attendance was not the list of papers on the program, for these were very few in number, totalling but seven. Instead the attraction appeared to be some unusual social features and entertainments.

It need hardly be said that the present House of the Society was wholly inadequate to accommodate the convention, and no attempt was made to use the House even for headquarters. Instead, through the courtesy of the New York Edison Co., the use was secured of the very handsome and convenient auditorium and club rooms in the upper stories of the company's sub-station at 44 West 27th St. These rooms were handsomely decorated for the occasion and the Society enjoyed the most comfortable and pleasant meeting place that it has had for its New York meeting in many years.

Tuesday evening's session opened at these rooms with the address of President John R. Freeman, who chose for his subject, "The Prevention of Theater Fires." As most of our readers know, Mr. Freeman ranks among the foremost engineers in this country, and indeed in the world in the field of scientific fire prevention; and his address, which is printed nearly in full in this issue, was received with great interest.

For the business session on Wednesday morning a genuine novelty was in store for the visitors. By the courteous invitation of The Hamburg-American Steamship Co., this session was held on board its new steamship, the "Amerika," which was lying at the company's pier in Hoboken in readiness to sail on her next transatlantic voyage on Saturday. There are very few steamships afloat having an assembly room capable of accommodating a meeting of such a large society; but the "Amerika" is the largest vessel in the world. Her dining saloon has seats for 400 persons, and it was here that the meeting was held.

The session was opened with a pleasant address of welcome by Mr. Emil Boas, General Manager of the Hamburg-American line, and then followed the report of the Council and the usual routine business. In the Council report we may note the election of the venerable Chas. H. Haswell, the first Chief Engineer of the U. S. Navy to honorary membership in the Society.

Regarding the house for the national engineering societies, made possible by the generosity of Mr. Andrew Carnegie, Mr. C. W. Hunt reported for the committee that it was hoped to hold the annual meeting of December, 1906, in the new house, which announcement was greeted with applause.

For the present house of the society, at 12 W. 31st St., an offer of $115,000 has been refused, and the price now set on the property is $125,000. Rules have been adopted for the organization of local sections of the society, but no such branches appear to have been formed.

The spring meeting of 1906 is to be held at Chattanooga, Tenn.

The financial statement showed a gross income for the year of $42,615, and a gross expense of $41,164. Of the total expenses, about $15,000 was on account of publications, about $10,000 for salaries in the Society's office, about $5,000 for the Society's house, and $10,000 for all other expenses. The total membership of the Society was 2,915 by the July catalogue.

A report was presented by the Society's committee on standards for machine screws presenting proposed standards for form of thread, diameters, threads per inch, proportions of heads, etc. These standards will doubtless be adopted and come into general use by makers and users of machine screws.

Following this came a technical paper by Mr. Jay M. Whitham, of Philadelphia, describing a number of tests of natural gas as a steam boiler fuel. The results of the tests were summarized by Mr. Whitham at the conclusion of his paper as follows:

(1) There is but little advantage possessed by one burner over another.

(2) As good economy is made with a blue as with a white or straw flame, and no better.

(3) Greater capacity may be made with a straw-white than with a blue flame.

(4) An efficiency as high as from 72 to 75% in the use of gas is seldom obtained under the most expert conditions.

(5) The "air for dilution" is greater with gas than with coal, so that possible coal efficiencies are impossible with gas.

(6) Don't expect, in good commercial practice to get a boiler horse-power on less than from 43 to 45 cu. ft. of natural gas, the same being referred to 60° F. and 4 oz. pressure above a barometer of 29.92 ins.

(7) Fuel costs are the same under best conditions with natural gas at 10 cts. per 1,000 cu. ft. and semi-bituminous coal at $2.87 per 2,240 lbs.

This is based on 3.5 lbs. of wet coal being used per boiler horse-power per hour or 45 cu. ft. of natural gas.

(8) Expressed otherwise, a long ton of semi-bituminous coal is the equivalent of 28,700 cu. ft. of natural gas; while a short ton of such coal is the commercial equivalent of 25,625 cu. ft.

(9) As compared with hand firing with coal in a plant of 1,500 boiler horse-power output, coal being $2 per 2,240 lbs.— considering labor saving by the use of gas— natural gas should sell for about 10 cts. per 1,000 cu. ft.

During the business meeting a large proportion of the members were engaged in the inspection of various parts of the vessel, and all parts from the lofty deck over the navigation room to the engine room and stoke-hold were thrown open to the visitors, who were also entertained at a luncheon in the smoking room. The "Amerika" is nearly 700 ft. long, has the great beam of 74 ft. 6 ins., and the hull is 53 ft. in depth. She accommodates some 3,000 passengers.

After two hours spent on board the vessel the party walked to the adjacent station of the Lackawanna Railroad and boarded a special train of 12 cars for the H. R. Worthington Hydraulic Works at Harrison, N. J.

This vast plant is the largest in the world devoted to the manufacture of pumping machinery. The space under roof amounts to 40 acres. The great machine shop alone is a building 1,000 ft. in length and 123 ft. in width. The whole plant has been built and equipped throughout during the past three years and embodies all the latest improvements in machine shop practice. Particularly noticeable is the entire absence of either line shafting or steam piping for the supply of independent engines. A single power plant furnishes electric current, compressed air, water and gas to the various departments, and while the electric motor equipment aggregates some 3,000 KW., it is found that the average current output is little more than 500 KW. In fact, two 500-KW. generators supply the demand for both power and light.

On their arrival at the works, the visitors were first taken to the office building, where luncheon was served. Each visitor was then given a map of the works with the route for the inspection tour marked thereon in red and the rest of the afternoon was spent in going through the various buildings and examining the many interesting machines and processes.

In the evening the hall at headquarters was filled to hear a lecture by Prof. R. W. Wood of Johns Hopkins University on the "Photography of Invisible Phenomena." While the lecture discussed experiments of the physicist rather than the engineer, it proved exceedingly interesting to the audience.

BEARINGS.

Almost the whole of one session (the entire meeting comprised only two, or more properly two and one-half, technical sessions) was devoted to an open discussion of the topic Bearings. Great interest in the subject was evident, and twice the available time could have been spent on the subject with profit. As it was, the subject was merely opened up; no convergence of opinion concerning the important phases of the subject was apparent, and even general concordance on numerical data was absent. The pointed remark was made by Mr. W. S. Rogers (Bantam, Conn.) that the subject of bearings, being once brought up in the society, would continue as a perennial subject in much the same way as the Car-Coupler subject in the Master Car Builders' Association. The remark seems to hit close to the truth.

There were four discussions before the meeting in printed form, but the remaining discussion made no reference to these. Mr. Geo. R. Henderson (New York, N. Y.), drew attention to the fact that in locomotive practice it has been found detrimental to load a bearing eccentrically. In driving-axle bearings the distance from wheel hub to center line of frame bar being closely limited and subject to little variation, the length of a symmetrical bearing is equally fixed; the expedient of adding length to the box at its inner edge, thus producing a bearing unsymmetrical to its load, has often been found to produce heating or uneven wear. The increase of pressure at the outer edge of the bearing is easily calculated. Prof. R. C. Carpenter (Ithaca, N. Y.) spoke of bearing metals. He expressed the view that laboratory tests are very uncertain and misleading, and proceeded to outline the desired characteristics of a bearing metal, thus:

The bearing metal should be one that has considerable adhesion for a lubricant and is readily wetted by it. It should be softer than the shaft which it supports, so that in case of lack of lubrication, or in case hard gritty material gets in the bearing, the bearing material

would be injured rather than the journal. It should be hard enough, however, to retain its shape under any conditions of pressure or temperature which are likely to be imposed upon it by actual use. The melting temperature of the bearing metal should be less than that of the journal which it supports; but it should not be readily melted by changes in temperature which occur in practice. The bearing metal when melted should not possess the property of adhering or welding fast to the journal.

But he also said: "In my opinion there is no positive criterion, no single definition or specification, which can adequately describe a bearing metal which shall be universally satisfactory for all work and conditions." Other factors than those above indicated are of moment, for example, the expansion or contraction in cooling is of importance in determining how a bearing can be used; babbitt can be cast into a holding shell, while bronzes and brasses must be cast separately, machined, and then set into a shell. The so-called "genuine babbitt," consisting of 85 to 89% tin, 2 to 5% copper, and 7 to 10% antimony, is probably suited to a wider range of use than any other metal ever tried. Mr. Albert Kingsbury (Pittsburg, Pa.) described a speed, load and friction test of a group of three very large bearings (two 9 × 30 ins., one 15 × 40 ins.) made by the Westinghouse Electric & Mfg. Co., of East Pittsburg, Pa., for the Niagara Falls Hydraulic Power & Mfg. Co., of Niagara Falls, N. Y., in 1904. The thickness of the oil film in the large bearing was measured by a lathe indicator; this showed that under 94,000 lbs. load (157 lbs. per sq. in.) the film on the side toward which the shaft rotated was about 0.001-in. thick at 630 r. p. m., 0.002-in. thick at 1,150 r. p. m., and tended toward zero at about 300 to 400 r. p. m. The film on the near side was always from 0.0012 to 0.0018-in. thicker. The extreme test which ran smoothly was under 94,000 lbs. load (giving 157 lbs. per sq. in. on the large bearing and 164 lbs. per sq. in. on the smaller bearings) and 1,243 r. p. m. The bearings seized in a test run under 50.5 tons load and 1,286 r. p. m. Paraffine oil was used, being supplied to a wide groove in each bearing parallel with the shaft; the oil supply was cooled. Mr. C. W. Naylor (Chicago, Ill.) related the successful use of water for lubricating the bearings of a 5-in. jack shaft which sustained a heavy horizontal belt pull. The shaft was run with water (fed freely in a small stream constantly trickling through the bearings) for 11 years, after oils and greases had failed to keep the bearings cool. The bearings wore ⅛ to ⅜-in. sidewise in the direction of the belt pull and were not refitted; the shaft showed no wear.

Mr. G. W. Dickie (San Francisco, Cal.) cited the thrust-bearing of the screw steamship as a very difficult kind of bearing. The load in such a bearing is divided among a large number of horseshoe thrust bearing rings, held in a casting. As the shaft and bearing frame reach different temperatures they will expand differently, thus tending to throw more load on the forward ring if the shaft is hotter than the frame, and on the aft ring if the frame is the hotter. In such bearings the horseshoe rings are always water-cooled. Mr. Dickie claims the first use of independent water cooling for the individual rings. For designing, it may be assumed that two-thirds the I. HP. is effective in advancing the ship, and the thrust may be computed from this.

Mr. G. M. Basford (New York, N. Y.) referred to the specially severe conditions of railway bearings, particularly those of locomotives. Fluctuating load and entrance of grit require a larger factor of safety than used elsewhere. Crank pins are loaded usually to 1,500-1,700 lbs. per. sq. in., and are lubricated easily; wrist pins are loaded to 4,000 lbs. per sq. in.; axle bearings have very much lower loads, from 200 to 220 lbs. per sq. in.; car axle bearings are loaded to 300-325 lbs. per sq. in. As the load may concentrate, however, these figures are somewhat misleading when viewed as actual loads.

Mr. P. H. Been (Milwaukee, Wis.) reported figures for Corliss engine practice. The best grade of babbitt is used in the shaft bearings of Corliss engines, the babbitt being cast in place, hammered tight, and then bored 1-64-in. larger than the shaft diameter. Pressure oil cups are used, feeding generally at the top of the bearing; mineral oil is commonly used. Provision for cooling the bearings is usually absent. In some cases the lower shell of the shaft bearings has been given a water jacket, but generally in such cases the jacket subsequently has not been used. The load is usually limited to 140 lbs. per sq. in., speeds up to 155-170 r. p. m. being employed. Horizontal engines of large size have usually four-part shaft bearings, comprising one fixed and one adjustable side piece, and top and bottom section. Vertical engines have generally two-part bearings, the lower segment being self-alining.

Mr. A. M. Mattice (Milwaukee, Wis.) drew attention to the frequent neglect of properly relieving the sides of bearings, designing oil grooves properly, or rounding their edges. Speaking of the several oiling systems in common use, he ascribed special importance to the "flooded" system, in which a bearing is supplied with as much oil as will flow through it. Central lubrication, connection with flooded oiling, is well worth the careful attention of engineers. The permissible temperatures of bearings are often restricted to a low limit by engineers in the fear that the oil may be injured; but much of this feeling appears to be a survival of the days of animal and vegetable lubricants. An examination of a large number of engines in service showed more bearings hotter than 135° F. than cooler, and some cases of 150° were observed, one even 180° F., without showing any trouble. Where electric generators are direct-connected to the engine shaft, the bearings are subject to greater temperature rise than otherwise, as they are more shielded, have the hot generator nearby, and receive less ventilation than in ordinary service.

Mr. H. K. Jones (New Britain, Conn.) reported a case where a large amount of shafting required about 25% less power to drive it after a heavy black oil which had been used was replaced by engine oil. Much of this shafting was equipped with both ring and suction oilers; it was found upon examination that the oiling rings were all stuck fast, the oil having thickened around them. The suction oilers remained operative. He advocated fitting all generator and motor bearings with a suction oiler at the center in addition to the ring oilers.

Mr. Oberlin Smith (Bridgeton, N. J.) contributed figures for bearing pressures from power press practice. In a well-designed toggle-press he found the toggle-pin to be subjected to a pressure of 20,000 lbs. per sq. in. of total projected area; such a bearing, while very slow moving, has no reversal of stress to aid in spreading the lubricant. The toggle levers in this case were of gun-iron, the pin of steel, hardened and ground. The eccentric of another press, 8 ins. diameter by 3 ins. thick, carried at maximum load a pressure of 7,000 lbs. per sq. in. of total projected area, although probably but a small part of this area was effective in carrying load. The main journal in this press was loaded to 3,500 lbs. per sq. in., if the load be considered uniformly distributed. This eccentric shaft runs at 100 r. p. m. A flywheel running loose on this shaft, having a bearing pressure of only 50 lbs. per sq. in., gives more trouble through wear than any other bearing in the machine, possibly due to the wear being constantly at the same point of the shaft circumference.

Mr. F. W. Taylor cited the case of a mill where the shafting was forced to carry much more than its intended load, and where, therefore, some shaft bearings failed and others showed by heating and wear that they were worked to their limit. He will contribute to the society's proceedings the numerical data of those bearings which appeared to be working about at the limit. He cited at the meeting only one case: this was a ball-and-socket or self-alining hanger bearing, with ring or chain feed and a babbitted box; its load was 40 lbs. per sq. in. projected area, and its surface speed 10 ft. per second. Mr. Taylor also offered this warning concerning figures for ball bearings: any figures based on less than two or three years' service are likely to be misleading or worthless, as in reasonably good construction the initial failure by fatigue does not begin before such period.

Mr. R. H. Rice (Swampscott, Mass.) reported that in the practice of the General Electric Co. bearing pressures of 30 to 80 lbs. per sq. in. are used, averaging perhaps 40 lbs. Higher pressures are used only where the rubbing speed is small. At speeds of 400 to 1,200 ft. per min. these pressures are not far from Thurston's rule: The product of speed in feet per minute and pressure in pounds per square inch should not exceed 50,000. Oiling rings, where used, should not be over 8 ins. apart. Bearings 12 ins. or more in diameter should have a circulating system of oiling. The step bearings of the Curtis vertical steam turbine support the shaft by oil pressure, which raises the shaft 0.003 to 0.005-in.; radial grooves are provided in the face of the shaft. Sometimes such machines are fitted with two step-bearings, one above and one below, the upper being supported on springs so as to take about half the load. Such bearings, where the shaft passed down through the bearing, have an annular bearing surface, and the oil is fed to an annular groove in the bearing ring; the oil consumption is greater than in the bottom bearing, as there are two edges of outflow. He cited several of these step bearings, giving diameter, load, and oil consumption. In one case the load is 52,000 lbs., the speed 750 r. p. m., the step has 16 ins. diameter, and the oil flow is 3½ gals. per min.

Much of the discussion dealt with ball and roller bearings, but this was of much less practical value than the discussion of sliding bearings. Messrs. F. Mossberg, Chas. R. Pratt, S. S. Eveland, W. S. Rogers, H. Hess, and some others contributed to this discussion. Mr. Mossberg recommended that 20 rollers be the smallest number used, that they be at least 1½ diameters long, and not too hard in temper; the box should, however, be as hard as possible, and the cages should be preferably of bronze. Mr. Pratt cited the case of a roller thrust bearing which succeeded where all other types of bearing failed; it has cylindrical rollers ½-in. diam. by ¼-in. long, with corners rounded to give 3-16-in. bearing length, loaded to 111-114 lbs. per roll. Mr. Eveland emphasized the importance of securing balls accurately sized, and noted that ball and roller bearings must always be oiled. The rolling surfaces should always be hardened and ground. The crushing strengths of balls, which seem to vary as the square of the diameter, are not sufficient to determine the proper loading, speed being equally important. The proper temper of balls depends somewhat upon the conditions of use: glass-hard balls are used in some typewriter bearings, while for conditions of special shock a drawn temper is employed; both these cases are extremes, not generally appropriate. Mr. Rogers asserted that the 1-in. ball is the best ball in the market; he gave 1,000 lbs. as the maximum loading for this size, and 200 lbs. for the ½-in. ball. In his practice, covering over a million balls, these loads have been found absolutely safe, no balls breaking. Mr. Hess presented a large number of drawings of ball bearings designed in Germany, and stated that German tests have shown that for ball bearings the friction of rest does not differ appreciably from the friction of motion.

REINFORCED CONCRETE.

A paper by Mr. E. N. Hunting (Pittsburg, Pa.) described a reinforced-concrete machine shop at McKees Rocks, near Pittsburg, under the misleading title, "Reinforced Concrete Applied to Modern Shop Construction." The shop described has a main aisle containing runways for traveling cranes, and two side aisles. The main aisle is roofed with reinforced-concrete slab construction carried on arched beams with tie-rods. There are many features of interest in the design and execution of the work, but they are not very completely or clearly described in the paper. We hope to reproduce the substance of the paper in a later issue. Of the discussion on this paper we can for lack of space give only a few extracts. Mr. George Hill (New York, N. Y.) recommended that reinforced-concrete buildings when on yielding foundation soil should have a slightly

flexible wall construction; he has used a 2-in. coat of cement and hard plaster on expanded metal for this purpose (Elizabethport shops of the Central R. R. of New Jersey). Such construction, he believes, is, however, of wider value, being preferable to 4-in. concrete and to brick walls. He advocated "translucent fabric" for skylights, and the use of flat roofs without provision for drainage; in the latter case, however, the skylights should be steep enough not only to drain but also to prevent snow lodging on them. Prof. R. C. Carpenter (Ithaca, N. Y.) stated that in his experience the use of reinforced concrete for roof-carrying members is inadmissibly expensive. In a stockhouse which he designed for a cement company the cost of the roofwork ran up to $15 per cu. yd., though every facility for cheap work was at hand. In a subsequent design he used reinfroced concrete up to the roof only, and put on a steel roof, at large saving. The large coefficient of expansion of concrete is another reason why the roof is a poor place for concrete. He even went so far as to state his belief that reinforced concrete, while an excellent material in the first story, should be replaced by concrete blocks (and steel framing?) above this level. Various members asked for more detailed data on the building described in the paper.

FLOW OF AIR THROUGH CIRCULAR ORIFICES UNDER LOW HEADS.

A long experimental investigation was reported by Mr. R. J. Durley (Montreal, P. Q.) in a paper entitled "On the Measurement of Air Flowing Into the Atmosphere through Circular Orifices in Thin Plates and Under Small Differences of Pressure." The work covered heads of 1-in. to 5 ins. water, and orifices up to 4 ins. diameter. The following formula was adopted to express the results:

Discharge, in pounds per second,

$$= 0.6299\ C\ d^2 \sqrt{\frac{i}{T}},$$

where C is an experimental coefficient;
d = diameter of orifice in inches;
i = pressure difference in inches of water;
T = absolute temperature of the air, Fahr.

The following values were found for the coefficient C:

COEFFICIENTS OF DISCHARGE FOR VARIOUS HEADS AND DIAMETERS OF ORIFICE.

Diameter of Orifice Ins.	1-in. Head.	2-in. Head.	3-in. Head.	4-in. Head.	5-in. Head.
5/16	0.603	0.606	0.610	0.613	0.616
½	0.602	0.605	0.608	0.610	0.613
1	0.601	0.603	0.605	0.606	0.607
1½	0.601	0.601	0.602	0.603	0.603
2	0.600	0.600	0.600	0.600	0.600
2½	0.599	0.599	0.599	0.598	0.598
3	0.599	0.598	0.597	0.596	0.596
3½	0.599	0.597	0.596	0.595	0.594
4	0.598	0.597	0.595	0.594	0.593
4½	0.598	0.596	0.594	0.593	0.592

(Barometer at 30 ins.)

The general conclusions are thus stated:

(1) The coefficient for small orifices increases as the head increases, but at a lesser rate the larger the orifices, till for the 2-in. orifice it is almost constant. For orifices larger than 2 ins. it decreases as the head increases, and at a greater rate the larger the orifice.

(2) The coefficient decreases as the diameter of the orifices increases and at a greater rate the higher the head.

(3) The coefficient does not change appreciably with temperature (between 40° and 100° F.).

(4) The coefficient (at heads under 6 ins.) is not appreciably affected by the size of the box if the ratio of the areas of the box and orifice is at least 20:1.

The orifices used were bored (straight) in iron plates No. 15 B. & S., or 0.057-in. thick. The experiments were made at McGill University, Montreal, by Messrs. F. E. Sterns and G. M. Smith.

A paper was read by Mr. R. H. Fernald (St. Louis, Mo.) on "The Preliminary Producer-Gas Tests of the U. S. Geological Survey Coal-Testing Plant at St. Louis." The paper gives confessedly only general results, as detailed or specific results await publication by the government.* The general result may be here quoted: that coal gives closely 2½ times as much effective power, when utilized by gas-producer and gas engine than when used in a non-condensing Corliss steam engine using 26.3 lbs. steam per horsepower hour.

In the discussion of this paper Prof. F. R. Hutton (Secretary) confessed that his chief object in inviting this paper for the meeting was to lead up to the adoption of a standard code for conducting gas-producer tests.

A very lengthy paper on "The Pressure Drop through Poppet Valves" was presented by Mr. C. E. Lucke (New York, N. Y.), who reported the results of an experimental study made by Messrs. R. M. Strong and F. R. Hollman at Columbia University. As the secretary stated in outlining the objects of the paper (in the absence of the author), "this is a paper of record," with which characterization it may here be passed over. The paper was not read and there was little discussion of direct value. The paper is to be supplemented, according to the secretary's statement, by a brief summary of the conclusions inferred from the work, at present not stated in the paper.

Much interest was aroused by a paper entitled "Test of Elevator Plant in the Trinity Building, New York City," by Mr. A. J. Herschmann (New York, N. Y.). The elevator plant in question comprises ten elevators of the direct plunger type, about 270 ft. maximum travel, the building having 21 stories. The elevators were intended to run at 600 ft. per min.; speeds from 400 to 885 ft. per min. were shown in tests. The paper and the discussion on it are reprinted in condensed abstract elsewhere in this issue, and need not be further mentioned here.

The closing paper of the meeting was "The Realization of Ideals in Industrial Engineering," by Mr. H. F. J. Porter (New York, N. Y.). Some extracts from this paper are given elsewhere in this issue. At the meeting the author supplemented it by a great number of lantern-slide views of shop "Welfare" devices, such as rest-rooms, sick-rooms, restaurants, gymnasia, etc., which are in use in various shops and factories. The discussion of the paper was rather restricted by lack of time, this being at the end of the last session. Mr. John Calder (Ilion, N. Y.) contributed a full description of the labor improvements in use at the Remington Standard Typewriter factory at Ilion, N.Y. Badge, bonus, suggestion, and first aid systems are in use there. Badges are given for service exceeding ten years, advancing in grade for each five years additional. The suggestion system does not apply to salaried officials and foremen; the latter are mentioned for special service in the monthly shop paper, the "Remington Bulletin." Mr. J. T. Hawkins (Boston, Mass.) presented the argument that all shop betterment methods are of no service in aiding to counteract the labor unions' limitation of productivity, and even themselves fail, frequently, through the opposition of the unions. Mr. H. Diemer (Indianapolis, Ind.) discussed various phases of the mis-direction of betterment efforts, and stated that even under the best guidance they sometimes fail by repelling the employees instead of enlisting their co-operation. Mr. W. H. Rogers (Bantam, Conn.) passed the sharp judgment on industrial betterment efforts that they are all "nice advertising schemes" and nothing more.

THE MAGNITUDE OF THE IRRIGATION WORKS now under construction by the U. S. Reclamation Service in the West is shown by the following statement, which has just been issued by that branch of the U. S. Geological Survey:

A resume of the work performed to date shows that 77 miles of main canal, 54 miles of distributing system, and 186 miles of ditches have been constructed, including dams, headworks, etc. Tunnels having a total of 3½ miles have been driven, including more than a mile of the great Gunnison tunnel. More than 250 miles of telephone lines have been installed and are in operation; 126 miles of wagon road, many miles of which cut out of solid rock in almost inaccessible canyons, bridges, and 50 office and other buildings have been constructed.

The works above mentioned have called for the excavation of 9,350,000 cu. yds. of rock and earth, the laying of 70,000 cu. yds. of concrete, 12,000 cu. yds. of rip-rap, 190,000 sq. ft. of paving; 150,000 lin. ft. of piling and 10,000 ft. of bearing piles have been driven. There have been purchased 130,000 lbs. of railroad iron, 250,000 lbs. of structural steel, 600,000 lbs. of cast iron, 1,750,000 ft. B. M. of lumber, and 78,000 bbls. of cement. The Government has erected a cement mill at a cost of more than $100,000, which has already turned out 150,000 bbls. of cement, and is now furnishing about 300 bbls. per day. The saw mills operated by the Service have cut 2,880,000 ft. B. M. of lumber from the Government forests. Eleven irrigation projects have been approved and are under actual consideration. Their estimated cost is nearly $30,000,000.

THE SAFEGUARDING OF LIFE IN THEATERS, A STUDY FROM THE STANDPOINT OF AN ENGINEER.*

By John R. Freeman.†

It is a fair and moderate statement that the present practice of the art of fire prevention as applied to theaters and buildings of public congregation, is from ten to twenty years behind the fire protection of large industrial works, and true that the fire hazard to theater property in general, as measured by a comparison of insurance rates, is ten times as great for the modern theater as for the modern factory. All of this is unnecessary. It is a wrong against the public that should be righted. The safeguards needed are mostly simple. The main features of some of them are already worked out and well proved within the great factories which engineers build and manage. The additional safeguards required to be worked out, or adjusted for this special case, the automatic smoke vents, the safe proscenium curtain, the safe warming and ventilation, the proper arrangement of automatic sprinklers in stage and dressing rooms and storerooms, are within the field of the mechanical engineer and are mostly simple problems to solve when serious attention and skill are once directed to them.

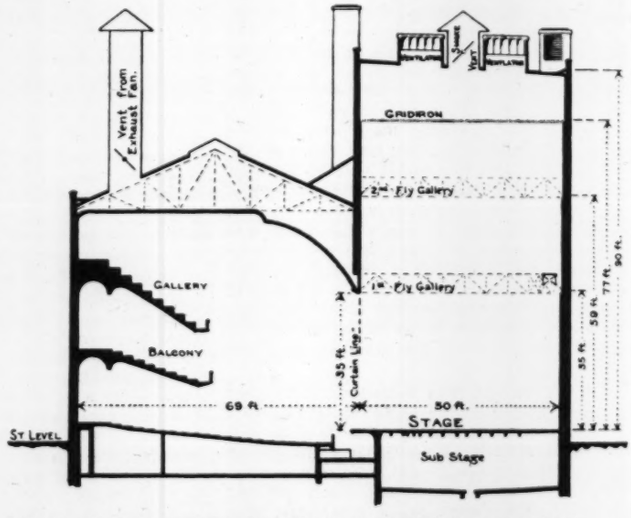


FIG. 1. CROSS-SECTION THROUGH AUDITORIUM AND STAGE, IROQUOIS THEATER, CHICAGO, ILL.

The Conditions.

In the course of my studies of the theater and auditorium problem, I have seen almost everywhere conditions affecting the safety of life that would not be tolerated for a moment by the managers of our best industrial works, and all from simple failure to know or to understand. For example, I have seen in one of the best New York theaters the wedge-shaped space beneath the sloping floor of the auditorium used as a storeroom for trunks and properties. This room was also the plenum chamber for the ventilation. Suppose that rats and matches, spontaneous ignition of oily material, or any of the obscure but frequent causes should start even a slow smoldering fire in this room. Why is it not foreseen that the smoke rising through the air ducts in the floor might throw the audience into a panic and cause great loss of life? In one of the most famous halls in America I found the portable wooden flooring, used sometimes to

*Bulletin 261 of the U. S. Geological Survey reports on the testing plant and some of the work.

*Abstract of Presidential address before the American Society of Mechanical Engineers at its annual meeting in New York city, Dec. 7-9, 1905.

†President Manufacturer's, Rhode Island and Mechanics' Insurance Companies, 815 Reaigan Building, Providence, R. I.

up and transform the main seating space into a ...m, stored in a dark passageway, which formed ...ain air chamber between the heating coils and the ...t hall, all thus kiln-dried to perfection, and when ...ved it to the manager and to an intelligent alder... committee and urged its immediate removal they ... no danger and thought me hypercritical and could not even see that automatic sprinklers would be of use in such a concealed storage space.

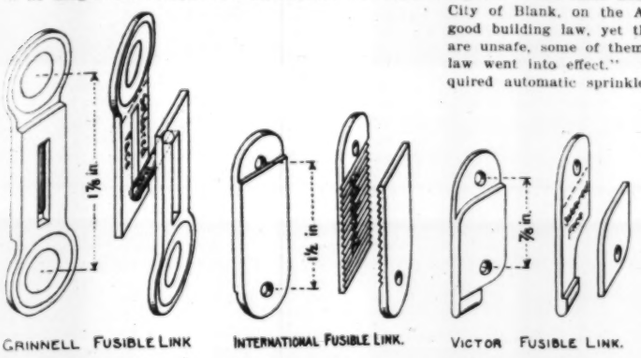


FIG. 2. FORMS OF FUSIBLE LINKS FOR AUTOMATIC FIRE SHUTTERS.

In Chicago, within a few months after the appalling disaster at the Iroquois Theater, the aldermen rescinded the rule calling for automatic sprinklers over the stages and rigging lofts of the theaters because the managers believed they "wouldn't do any good" and "might start a panic, should one happen to open prematurely." Every factory manager or mill engineer will admit the absurdity of such a statement. In Boston, the law still accepts the non-automatic sprinkler pipe to be opened by hand, a device which has now been generally discarded in factory fire protection in favor of the automatic.

Most important of all, I have found behind the scenes and in the mechanics' rooms a lack of the scrupulous neatness and order that characterizes a modern well-organized factory, have found a multitude of dark concealed spaces used as catch-alls and an apparent lack of appreciation by owner and architect, that a flood of daylight in storerooms, workrooms and dressing rooms is the best of all safeguards, by making dirt, disorder and dangerous rubbish conspicuous.

We cannot leave it to the underwriter to make the theater safe against fire. The able president of one of the largest insurance companies has said to me "as an individual, I would be very glad to see the theaters safe for the public which patronize them, but as an underwriter, I charge for the hazard as I find it and need not care particularly whether the rate is 1% or 5%." He tells me too that on the whole, the theater class at current rates is profitable underwriting.

We cannot leave it with the framing of a good building law. The same underwriter also said to me, "The City of Blank, on the Atlantic Seaboard, has a pretty good building law, yet the city is full of theaters that are unsafe, some of them constructed since the building law went into effect." The Chicago Building Law required automatic sprinklers over the stage; until after the Iroquois, not one had ever been put in. Then in the effort to perfect the enforcement of the law, they cut out the requirement for sprinklers.

How can we transfer the care and the precautions of the modern factory to the modern theater? How can we bring the manager, the architect, and the official guardians of public safety—the fire chiefs and the public inspectors of buildings to understand and introduce the well-proved safeguards and to be critical about that perfection of detail on which safety depends? How can we bring the public to demand these things?

THE LESSON FROM ACTUAL FIRES.

I first became actively interested in this question by the burning of the Iroquois Theater at Chicago a little less than two years ago. I examined the structure before any of the wreckage had been moved, listened to evidence before the coroner's inquest, counseled with the mayor and committee of the board of aldermen, questioned eye witnesses and inspected many other theaters in the effort to reach a clearer understanding of their special hazards.

This fire occurred at a Wednesday afternoon matinee in the midst of the holiday season when the theater was crowded largely with pleasure parties of women and children. With admirable promptness the chief of the public fire department and an efficient force of firemen were on the ground within little more than five minutes from the first alarm, but even by that short time most of the victims had already become suffocated. Some of the cooler headed, who apparently followed the maxim for safety, "Remain in your seat and avoid crushing at the exit," were suffocated in the gallery, where they sat.

What has been called the irony of fate is found in the fact that the scene of this appalling disaster was the newest of Chicago's theaters, a building of fireproof construction that justified the name so far as the building itself was concerned. Little except scenery, decorations and upholstery was damaged. It is true that there had been shameful neglect in important details of fitting up, that fire hose on the stage had been delayed, that fire pails and soda-water fire extinguishers were absent, and that the ventilating skylights over the stage were blocked so they could not slide open, and that exits were poorly marked, but I have come to believe that had these all been in the condition commonly found in American theaters the result of the fire might have still been appalling, and it is because I am sure the great lessons of this and the other great theater catastrophes have not been properly heeded that I speak on this topic to-night.

The great lesson of the Iroquois fire was only a repetition of a lesson that has been given several times before and each time forgotten. The recurring formula is:

(1) A stage crowded with scenery.
(2) The sudden spread of the flames over this scenery.
(3) The opening of a door in the rear of the stage, an inrush of air.
(4) Scant smoke vents over the stage, an outburst of smoke under the proscenium arch.
(5) Death to those in the galleries.

In 1881, at the Ring Theater disaster in Vienna, with about 1,800 in the audience, careless lighting ignited a "hanging border," a large door in the rear of stage was opened, letting in a blast of air that drove the smoke through the proscenium arch; the iron curtain could not be lowered; special exit doors were found locked; 450 were killed, mostly in the upper gallery.

In 1887, at Exeter, England, fire caught on a stage crowded with scenery. Within about 5 minutes from the outbreak of the fire 200 were killed, mostly in the upper gallery.

In 1876, at Conway's Theater, Brooklyn, N. Y., the stage was crowded with scenery; a border caught fire; the blast of suffocating smoke was increased by the opening of large doors in the rear of stage; about 300 were killed, all in the upper gallery.

Note the suddenness, the suffocation, and the fact that the fatalities are nearly all in the galleries!

The Problem.

The amount of combustible material on the stage in a great spectacular piece is surprisingly large. On the Iroquois stage at the time of the fire there was more than 10,000 sq. yds. of canvas, or 2½ acres, and in addition about 3,000 sq. yds. or half an acre of gauze. To hang this required more than 10 miles in length of ⅝-in. Manila rope, and in the frames, battens, braces, profiles and set pieces the stage carpenter estimates there was about 8,000 sq. ft. of white pine lumber. The total weight of this fuel was more than 10 tons, all dry as tinder and all set or hung in a way to give the quickest possible exposure and spread to the flames. The paints used by the scene painter are not dangerous. They are almost entirely put on with water and glue, and they tend to make the fabric a little less readibly combustible.

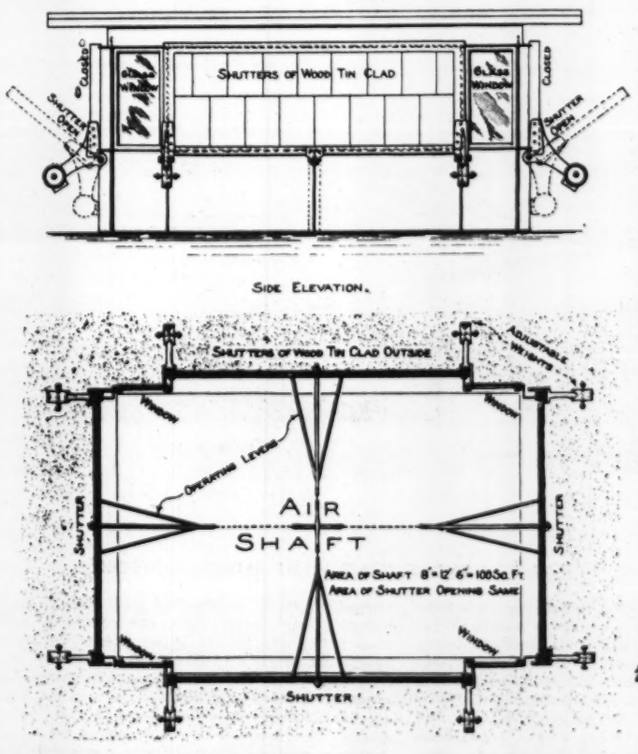
It is a very rare case that so much scenery is found upon a stage, but if as is more common it were only one-fourth part as much, it is plain that the fuel supply is sufficient to send out an enormous volume of suffocating gas. Indeed, I have computed that merely the quick burning of this 160 lbs. of gauze that hung over the Iroquois stage would heat a volume of air equal to that contained in the space above the proscenium arch to 1,000° Fahrenheit. There is good testimony to the effect that only about two minutes' time elapsed after the first spark until all the upper scenery was in flames. Only from three to four minutes' time elapsed before the large space of the hanging loft was so filled with fire that the flames and smoke rolled out beneath the proscenium arch into the top of the auditorium; then came suffocation and death.

THE MAIN PROBLEM IS TO GIVE PROMPT AND CERTAIN VENT TO THIS SMOKE AND SUFFOCATING GAS, ELSEWHERE THAN THROUGH THE PROSCENIUM ARCH.

The Solution.

SMOKE VENTS.

The ordinary construction with a high spacious chamber for the hanging loft above the level of the proscenium arch makes it a simple matter structurally to keep this fire and smoke out of the auditorium, and no matter how great the mass of flaming scenery a smoke vent of



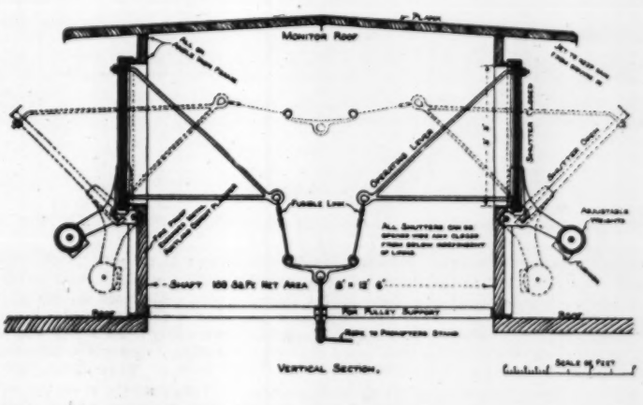


FIG. 3. DESIGN FOR SMOKE VENT WITH HINGED SHUTTERS.

1/8 or 1/10 the area of the stage, if instantly opened, would probably have saved all of this terrible suffocation at Chicago, at Exeter, at Brooklyn and at Vienna.

Fig. 1 shows a cross section of the Iroquois through auditorium and stage. The form is typical and about the same in all its first-class theaters. To one who has not been behind the scenes and up to the gridiron, the surprising thing is the great head room, commonly 70 ft. from stage to gridiron and 80 or sometimes 90 ft. from floor to roof, and necessarily more than double the height

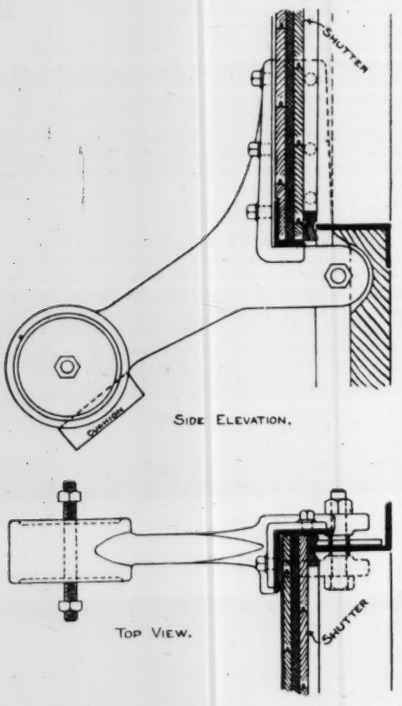


Fig. 4 Detail of Counterweights for Hinged Shutters for Smoke Vents.

of the proscenium arch, into which are hoisted the great sheets of canvas on which the scenes are painted.

The conditions are plainly similar to that of the fireplace in our living room magnified 10 or 20 diameters. Note how admirably the high space over the stage screened by the arch is adapted to give the best of chimney draft, and not give us a smoky fireplace. The roaring fire on our hearth sends 95% of its heat up the chimney and gives out no smoke into the room, if only the chimney be properly designed and the damper open. An ordinary rule is to make the throat of the chimney at least 1/10 the area of the fireplace opening, or it may be stated that the space through the damper should be 1/8 the area of the hearth, and when we simply provide an adequate chimney area and a damper that will surely open we shall have adopted a safeguard that would have saved four-fifths of those who perished at the Iroquois Theater fire, regardless of defective curtain, defective exits and absence of fire hose on the stage.

EXISTING REGULATIONS AND PRACTICE.—In a way it has long been recognized that there should be a large ventilator over the stage, and one city has copied from another the building law that in the case of New York City, reads as follows:

There shall be provided over the stage metal skylights of a combined area of at least 1/8 the area of the stage fitted with sliding sash and glazed with double thick sheet glass . . . the whole of which skylight shall be so constructed as to open instantly on the cutting or burning of a hempen cord. . . . Immediately underneath the glass of said skylight there shall be wire netting . . . etc.

The evident purpose of the thin glass is to cover the opening with something that will break out under heat if the mechanism for sliding the cover off fails. The wire netting is to catch any piece of broken glass from falling to the stage.

The building law of the London County Council reads much the same, save that its ratio is 1/10, and perhaps that is where the rule began. Some of the leading American cities make the proportion 1/10. In the revised Chicago ordinance, notwithstanding their fearful lesson, they are content with ventilators 1/20 the net area of the stage, because, as one of the Aldermanic Committee gravely assured me, "If the area was made too large, it might cause a down draft."

The idea of a large ventilator expressed in these rules is all right, but the execution is commonly all wrong, and needs some good engineering to provide a design of damper with careful details that will be sure to work. Note the antiquated suggestion of the burning of a hempen cord when fusible links have been used on the fire doors in your factories for 20 years! There is no good reason to expect that the hempen cord in this position in smoky atmosphere from which oxygen had been largely removed would burn off until a majority of those in the gallery had been suffocated.

In one of the newest and best of the New York theaters I found the ventilator had a broad sheet of heavy canvas laced tightly across its opening with marline, because, as the stage carpenter told me, the cracks around the ventilator let in too much cold air. No building inspector had objected, and the carpenter could not be made to see any danger. "It would burn off in any bad fire," he said. So it might, but not until those in the gallery were mostly dead. The requirement of thin glass in the building law is well meant, but it would be too slow in breaking out. Remember how quickly unconsciousness of suffocation comes in an atmosphere of smoke. The wire netting called for is a positive danger as often applied.

One of the most experienced theater managers in America told me frankly that he knew the smoke vents on the theater which he then occupied would probably not open in winter, unless a man should first pry them loose with an iron bar, but, said he, "I have not heretofore seen anything better," and so, after the Iroquois, he had set his stage carpenter at work to invent something.

Doubtless there are many good smoke vents here and there that have been designed and built with skill and conscience, for the problem is not so very difficult; but I have not yet seen one of these vitally important pieces of apparatus in which the design had been worked out with reasonable degree of perfection of detail. "Something good enough to pass the building inspector" appears to have been the current specification, instead of the proper specification of "Something of ample area that will be sure to open wide instantly, without human intervention, and that cannot be stopped by warping, settlement, obstruction, frost, snow, rust, dirt or ordinary neglect."

I do not know who first fixed this ratio of 1/10 for size of ventilator, the same figure that appears in the rule of the London County Council. Its author may have built wiser than he knew, or may have taken it from the well-proved ratio of the fireplace chimney. It works out as safe when computed mathematically on theoretic grounds from the uncertain data. The material is so favorably disposed for ignition that the rapidity of combustion is largely a question of the air supply. I am led by computation and precedent and the need of some factor of safety to concur in the wisdom of the ratio of 1/8 or 1/10 as already specified by the building laws of the great majority of our American cities, and believe it wise to base it upon the gross area of the stage floor rather than upon proscenium opening, or cubical contents of the stage.

I have seen here in New York in a recent theater a case where the inspector had, perhaps temporarily, forgotten the wording of the law and figured it on the area directly in behind the curtain, omitting much of the floor space at the side. This is wrong, because, given a large stage, there is a well-proved tendency to permit an unnecessarily large amount of combustible material upon it, and it not infrequently happens that the scenery of next week's new attraction may be found stored at the side and rear during the Saturday night performance.

THE AUSTRIAN EXPERIMENTS.

Following the great theater fire in Vienna, a committee of the Austrian Society of Engineers (Vereines Techinker, in Ober Osterreich) built a model of the Ring Theater on one-tenth of its lineal scale, which thus contained only 1/1,000 of the cubic contents of the original, and made many tests and experiments.

The experiments were divided into two groups, the first comprising those in which no ventilators were opened over the stage, while in each of the experiments of the second group two ventilators were opened, having a combined area which according to the scale of their drawings was very nearly one-tenth of the area of the stage. In the first series of tests made by igniting sheets of paper hung to represent the scenery, but containing proportionally far less combustible material than is often found on a theater stage, they found that the expansion of the air caused by the heat quickly forced the curtain outward from the proscenium arch, and within about 30 seconds from lighting the fire, this heating of the air produced an excess of atmospheric pressure, much greater than that of the ordinary pressure of city gas, thereby explaining why it was that the lights in the Ring Theater became so quickly extinguished after the outburst of the fire.

In the second series of these Austrian experiments their models of the ventilating shafts were closed by sheets of paper, and as soon as these burned open all excess of air pressure disappeared from the auditorium, and, indeed, the updraft drew the proscenium curtain inward over the stage. During these experiments an unexpected warning was given against covering smoke vents by wire screens, for it was found the flying bits of charred paper carried up by the draft almost completely closed them. To show how little this warning of the Austrian Society of Engineers has become incorporated in current practice, I may call attention to the building law of New York City, which requires that underneath all of these skylight openings designed as smoke vents wire netting must be stretched, the law apparently never considering how quickly this will become so clogged as to destroy in large part the utility of the smoke vent. At my visit to the remodeled Iroquois I found the openings in their new ventilating shafts screened by wire netting in a way that would probably within a minute's time put them into a condition of uselessness because of the fragments of burning cloth and embers with which they would be immediately covered under the strong updraft.

The Committee of the Austrian Society of Engineers concluded that the outburst of flame and smoke into the upper part of the auditorium and the extinguishment of gas lights in a theater could all be prevented by providing adequate smoke vents over the stage, and places these smoke vents as the feature of first import in safeguarding life in theaters, and says that without them emergency exits and fire curtains will be of no avail, and in th's conclusion I most heartily concur. Regarding the mechanical construction of these smoke vents the Committee says:

It is necessary that these be opened instantly upon the outbreak of the fire; mechanical contrivances of iron to be operated by human means will certainly fail, for according to all experiences in theater fires thus far, fright on the part of the employees prevents the use of such arrangements.

They warned against automatic contrivances whose action may be interfered with in consequence of rust or expansion by heat and against sheet iron valves falling inward by their own weight, which might be restrained from falling open by the excess of pressure due to updraft, and, finally, recommended that these shafts be closed by a quickly combustible tissue of hemp or jute covered with varnish or celluloid and with a hole about 1½ ins. in diameter in the center to invite quicker ignition. Our Austrian friends were unfamiliar with the American fusible-solder link, which is certainly quicker and safer and more practical than any such tissue of varnished hemp.

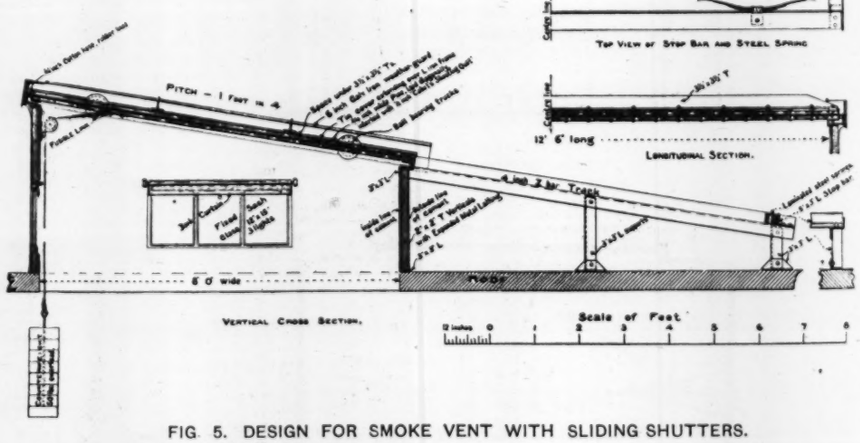

PITCH = 1 FOOT IN 4
6' 0" wide
VERTICAL CROSS SECTION.
TOP VIEW OF STOP BAR AND STEEL SPRING
12' 6" long
LONGITUDINAL SECTION.
Scale of Feet

FIG. 5. DESIGN FOR SMOKE VENT WITH SLIDING SHUTTERS.

FUSIBLE LINKS.—These links have been in common use on automatic fire shutters in our factories for nearly 30 years. Three types of these links are shown in Fig. 2. It is strange almost beyond belief how slowly and scantily these have found their way into the fire protection of theaters.

These links melt open at about 162° F., and thus will open long before flame reaches them. Their cost is trifling. Links like these shown in Fig. 2 tested to immediate rupture will break under a load of about 200 to 250 lbs., but can be trusted to sustain continuously a load of only about 50 to 100 lbs. All of the known solders that fuse at low temperature are subject to stretching or "cold flow" under long continued loads, unless these loads are made extremely small, and one of the most important features in the design of any such link is to

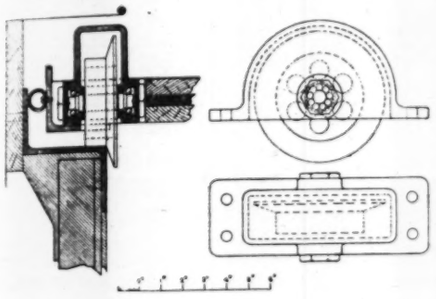


Fig. 6. Detail of Roller and Roller Track for Sliding Shutters for Smoke Vents.

make the direct stress upon the solder small and in tension over a large area, rather than by shear. The links shown will open with about the same promptness as an automatic sprinkler. At the top of a rigging loft over a fire like that on the Iroquois stage they probably would open within 20 to 40 seconds after the blaze got a good start.

The sensitiveness of the link or quickness of action under moderate degrees of heat depends on the thinness of the mass of metal to be warmed up and therefore on the rapidity with which it absorbs heat enough to melt the solder. These two characteristics, the weakness of the fusible solder under long continued strain and the necessity for rapid absorption of heat, limit the strength of fusible link that can be employed. In many situations a link is desired of such form and size that when inserted in a rope it can run over the ordinary pulley.

SMOKE VENT DESIGN.—Concerning the design of smoke vents those that I have seen in actual use have been, with hardly an exception, imperfect pieces of mechanical design. At certain of the most recent New York theaters I have found the type which appears to be the favorite for metting the New York building law set with such a clearance as to give a very unnecessary degree of ventilation which tempts the theater mechanic to stop the draft by some means that may prove dangerous. It is, moreover, so heavy and unwieldy that it cannot be frequently tested by opening and closing, and to wait for the burning of a hempen cord to open a device of this kind should be regarded as criminal negligence when it can be done so much better and quicker by the automatic fusible link.

To meet the proper suggestion that one should not merely criticise without presenting a better device, and as a means of illustrating that the problem can be solved along various lines of design, I have worked out two models shown in the accompanying drawings, Figs. 3 to 7. I am certain that with experience and constructing, one after another, these designs could be improved upon. It is best the total area of $^1/_{10}$ the stage be sub-divided into four independent units. The fundamental requirements are as follows:

(1) Absolute certainty of opening by force of gravity, in spite of neglect, rust, dirt, frost, snow or expansion by heat, twisting or warping of the framework.

(2) Quickness of opening to be secured by automatic links of the thinnest metal practicable and also by controlling the doors by a cord run down to the prompter's stand and to the station of the stage fire-guard.

(3) The operative mechanism of the smoke vent should be simple and massive, designed not as a watchmaker would build it, but more according to the standards of railroad service or rolling mill practice. The counterpoise weights should be heavy and a constant tension on the release cord of upward of 25 lbs. so that rust, cobwebs or temperature changes might not be of noticeable effect in the resistance to be overcome.

(4) The vent should be of such form that it can be tested daily or at least at the weekly inspection by partially opening it, preferably closing it again by means of the cord running to the prompter's stand. It may perhaps add to the safety if it is of such design that it can be used whenever needed for the ordinary ventilation of the stage, summer or winter, rain or shine, thereby keeping it under constant view and bringing into immediate notice any difficulty about its opening or lack of repair.

In the first of these designs submitted, shown in Figs. 3 and 4, the 8 ft. × 12 ft. opening, of which four would be needed, over the stage of ordinary size, has a roof for protection from rain and vertical sides that contain four small windows for admitting daylight to the rigging loft, but which can be closed by ordinary window shades for dark scenes. All necessity for the wire screen is avoided. The four shutters fall outward lest the pressure of the updraft tend to hold them shut, and are pulled open by force of gravity, opening to the full area called for. The pull on the rope holds them against their seat which, if made with a thin edge pressing loosely against fibrous material, as shown, will be more tight against cold air drafts than a common window sash or house door. Fusible links are inserted in each of the four branches of the cord. No sprinkler should be placed up within the monitor containing these links, and care should be taken that the links are of a thin, quickly sensitive type.

In the second design, Figs. 5 and 6, the sliding type is used. This obviously cannot be used as an ordinary ventilator in rainy days. The special effort in remodeling this from the current New York type has been, first, to place the glass in the vertical side so that no necessity for a wire screen remains. Second, to provide a better track and trucks and arrange the joints so that the leakage of air through the clearance space would not tempt the janitor to close the space by something that may interfere with the sliding open.

A third sketch, Fig. 7, shows an arrangement of a safety ventilating shutter that sometimes can be conveniently placed in the brick wall near the top of the rigging loft.

AUTOMATIC SPRINKLERS.

The second safeguard in order of importance is in my opinion a complete equipment of automatic sprinklers over the stage and throughout all rooms and nooks and corners except in the auditorium. I unhesitatingly recommend them as the best of all known means for promptly controlling a fire that has once got good hold in the scenery upon the stage of a theater.

It has been claimed that under the high rigging loft of a theater sprinklers at a distance of 60 or perhaps 80 ft. above the floor of the stage would be so remote from the flames that they would not open with sufficient promptness to be of material service. I am confident that this is untrue. The hot air from a fire quickly travels over a vertical distance of 60 or 80 ft. Not more than five to ten seconds' time would be required for this, and the conditions for pocketing and confining the heat in a small area in the top of the rigging loft of a theater are much more favorable than in many portions of factories ,where sprinklers are found to work successfully. One series should be placed below the gridiron and preferably another series above it, these not being vertically over one another. Those in the top series are as likely to open first, but it is well to be liberal and provide both series. A line should also run along the lower outer edge of each fly gallery. With care a skilful sprinkler fitter can readily place and guard all the heads and pipes so that the danger of breakage need be no greater than in a factory. The 162-degree solder should be used.

Stage scenery, while exposed to very rapid ignition, is equally well exposed to very rapid drenching, and the fact that we have so few actual records of what sprinklers can do in controlling a fire on the stage is due to the few instances where sprinklers have been installed in theaters, or have had an opportunity to demonstrate the work of which they are capable. At least there have been no failures, and we have one notable success to their credit, and this in a case where they had been put into a theater because a factory manager who was one of the stockholders had been satisfied of their efficiency by fires that they had extinguished in his cotton mill. This was at a theater in Woonsocket, R. I., in which a gauze piece took fire from the border lights prior to the performance, and sprinklers opened under the gridiron 65 ft. above the floor while other sprinklers opened under the roof 80 ft. from the floor. At theaters in Philadelphia, New York City and Providence, R. I., there have been notable instances of fires, when the audience was absent, from spontaneous combustion and overturned lamps, where the sprinkler extinguished the flames; and from Manchester, England, a case is reported of a fire in a "gauze sky," between the acts, extinguished by four sprinklers 30 ft. above the flies, so promptly, that although the stage and scenery were wet, the performance went on without the audience knowing just what had been going on while the curtain was down.

POSSIBILITY OF LEAKAGE.—A leading argument against automatic sprinklers has been the possibility that they would break open when there was no fire and thus injure the scenery. We have statistics to show how extremely small this danger really is. The records when I last compiled them showed that out of a total of something over 3,000,000 sprinkler heads scattered through more than 2,000 different factories, losses from premature discharge were occurring at the rate of about 50 sprinkler heads breaking open per year. This proportion of one sprinkler in each 60,000 springing a leak per year, when applied to the conditions in a theater that would commonly have less than 150 sprinkler heads over the stage, although they were put in both under and over the gridiron and under the fly galleries, would give a probability at any one particular theater of a leak once in 400 years. Should we admit, what is not certain, that the danger of knocking one of these sprinklers open by a blow is greater in the theater than in the factory with its moving machinery, it is plain that this danger of leakage is no just ground for excluding sprinklers from over a theater stage. Our insurance companies do not hesitate to recommend them for a packing and storage room over a quarter million dollars' worth of delicate silks or finest textiles, and so little do we fear the premature discharge that in the fire insurance we guarantee against this water damage with no additional charge.

The idea that the fine spray or rain of water from a single opened sprinkler head falling vertically and probably invisible to most of the audience could produce a panic within the audience, however much it might disturb the chorus is too absurd for serious argument. Sprinklers, although not so generally used over the stage as they ought to be, have been introduced here and there, and in some cities quite generally. I now have the record of about 150 theaters that have been fitted with sprinklers. I have sent a circular letter to the managers of many of these theaters asking for their experience. In no case did I receive an adverse criticism, and, in the majority of cases, they speak in most appreciative terms of the value of this safeguard.

FIRE CURTAINS.

The third of the safeguards demanding investigation is the curtain for closing the proscenium arch. With good smoke vents and thorough automatic sprinkler protection over the stage and with ample stairways from galleries, it is probable that the audience could escape from a situation as bad as that in the Iroquois, even though there were a very poor fire curtain, or perhaps no curtain at all; but in theaters, as in factories, it is wise to have a second and even a third line of defence, lest the first happen to be inoperative in the moment of need.

EXISTING PRACTICE.—The fire curtain for covering the opening under the proscenium arch in nearly all American theaters outside Chicago at the present time is made from a heavy canvas woven from asbestos fiber; and in English theaters the asbestos curtain appears to have been steadily gaining in favor because of its less weight and smaller cost in comparison with a curtain of sheet iron, stiffened by ribs. In Chicago with the failure of the Iroquois asbestos curtain and with the excellent corrugated iron curtain of the auditorium both before them, the Aldermanic Committee has made the steel curtain the rule. Chicago to-day leads the country in the substantial quality of its proscenium curtains, and in the present state of the art they merit little criticism except the absence of a positive down-haul and better holding and guiding in iron channels at the edge.

Like nearly all steel ribbed shutters they will warp and twist off their seats under 10 to 15 minutes of ex-

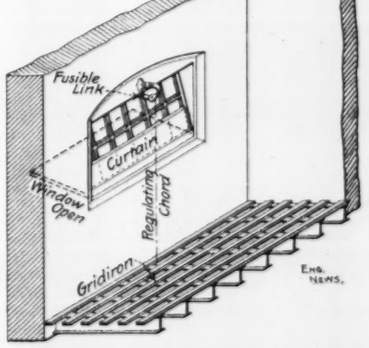


Fig. 7. Design for Smoke Vent in Brick Wall at Top of Rigging Loft.

posure to a severe fire unless securely held at edges, and should smoke vents be closed and sprinklers lacking and a back door open, their loose fit would let volumes of suffocating smoke and tongues of flame pass into the auditorium. With the smoke vents open and the draft therefore inward, they will serve their purpose until the audience has escaped and the firemen have arrived.

Special attention was directed to the asbestos curtain in the Iroquois fire, from the fact that the curtain, although promptly let loose, failed to fall; because, as some say, it was blown outward from the stage by the strong current of air; or because, as others say, it caught on certain of the electric light shields. The asbestos canvas soon fell as mere rubbish to the stage, but so little that resembled a piece of asbestos canvas

could be found on the stage that it was for some time believed that the curtain had not been made of asbestos.

It is now certain beyond question that this Iroquois curtain actually was made of a good ordinary commercial quality of asbestos canvas, and it was doubtless true that this Iroquois curtain was just as good as those which hang to-day in the majority of our theaters. I personally found fragments of this asbestos cloth in my first examination of the stage while everything was just as the fire left it, and later I secured samples which, although brittle, "rotten," or without cohesion of fiber, are in all respects similar to what I obtained by exposing a sheet of new, thoroughly first-class asbestos cloth to a moderate flame temperature for the space of 5 minutes.

The asbestos curtain at the Iroquois Theater was an utter failure in three different ways.

(1) As already stated, it could not be lowered, and stuck fast after descending a distance variously estimated at from ¼ to ½ the height of the proscenium arch.

(2) The Iroquois curtain was improperly hung, being supported at the top in part by being clamped between thin strips of pine wood about 4 ins. in width by ¾ in. in thickness. So tolerant is the public and so easy are public building inspectors, that I have myself seen more than one example of an asbestos curtain hung from a batten of white pine, to which it was nailed across the top.

(3) The asbestos canvas of the Iroquois curtain when exposed to actual fire lost its strength and fibrous quality almost completely and became so brittle that it would crumble under a very slight pressure, and became utterly incapable of withstanding the pressure of a strong draft of air, and too weak to hang up under its own weight.

ASBESTOS.—The word "asbestos" has become in the public mind a synonym for perfection in fireproof material, but the investigations now to be described have made me believe that a simple asbestos curtain of even the very best quality will not form a durable and certain fire screen for the proscenium arch when exposed to a bad fire.

Any asbestos curtain may be expected to resist the ridiculously inadequate test of the flame of a gasoline torch, and any well hung asbestos curtain, if it can be pulled down, will probably endure longer than the brief period of 2 or 3 minutes, within which it should be possible to empty any theater; and meanwhile it might serve a most useful purpose in screening the flames from direct view.

In opposition to the failure of the Iroquois curtain, we have an interesting test of the action of an asbestos curtain and smoke vents combined, in the fire that destroyed the Girard Avenue Theater in Philadelphia on Oct. 28, 1904, and which broke out about three hours after midnight on the stage when no one was present. On the arrival of the public fire department, three minutes after the first alarm, the flames were coming out of the skylight ventilators over the stage of ⅛ of its area, which it is stated had opened automatically. The firemen at first found no fire or smoke in the auditorium and the curtain hung there, and probably with the aid of the cool in-draft toward the stage kept flames out of auditorium for a period said to be 15 minutes. Shortly after this the fire somehow passed into the auditorium; doubtless around the edge of the curtain or by the curtain becoming ruptured by falling material.

While I regard this record as more of a triumph for the smoke-vent than for the curtain, it is of great interest to note that under existing conditions, whatever they were as to quantity of burning scenery, this curtain with the 1 to 8 smoke-vents open, lasted much more than long enough to have covered the escape of an audience. In all probability this fire was much less fierce and rapid than the Iroquois and had far less scenery on the stage.

In order to learn what difference there might be between different makes and grades of asbestos canvas, I obtained through various channels samples each from 3 ft. to 6 ft. square from all of the prominent American manufacturers of theater curtains and also from each of the American manufacturers of asbestos cloth. I also cabled to London and had an architect familiar with theatrical work collect samples of asbestos curtain cloth from the leading English manufacturers and dealers, under instructions to use every effort to procure some canvas that was woven from French or Italian or other than Canadian fiber.

When pressed hard for the pedigree of their samples no one of these makers would furnish asbestos canvas under a guarantee that it was made from anything other than the Canadian fiber, and, on chemical analysis, all of our specimens of canvas obtained either at home or abroad were found to be of a chemical constitution similar to that of the Canadian fiber.

The Canadian mineral is not the kind to which the name asbestos was first applied and strictly speaking is not true asbestos. It is a fibrous crystalline variety of serpentine, and contains about 13% of water in chemical combination, plus a little hydroscopic water, whereas the form to which the name asbestos was first applied contained no combined water whatever.

There are two or three minerals of very different chemical constitution which go under the name of asbestos:

(1) Chrysotile, which contains about 15% of water, 12.9% chemically combined and about 2% hygroscopic. This is essentially a silicate of magnesia.

(2) Tremolite, which is anhydrous, and is a silicate of lime and magnesia, with sometimes a little iron.

There is a third mineral which is asbestiform in character, a silicate of iron and magnesia, known as anthophyllite.

The first named loses its strength at about 660° C., or just below redness, on the drawing off of its water; but the last two containing no combined water stand more heat, and are said not to fuse until about 1,300° C., equal to 2,400°, is reached. We did not measure this.

The Canadian fiber is chrysotile. This now the common asbestos of commerce, and, possessing in greater degree than the others the properties required for spinning and weaving, has come to be the only kind used in the manufacture of asbestos canvas. The Georgia asbestos, although free from water in its chemical combination, and therefore not decomposing at low red heat, has for the most part a fiber too brittle for spinning and is used for purposes not requiring strength of fiber.

The anhydrous tremolite and amphibole asbestos are also found in Siberia and in South Africa, but all the anhydrous asbestos makes up an insignificant part of the asbestos of commerce, and although some of the cabinet specimens of anhydrous asbestos have long silky pliable fiber, we were unable to anywhere obtain cloth made from anhydrous asbestos.

Several kinds of asbestos canvas can be procured in the market. There is a distinction sometimes made in the trade between "absolutely pure" asbestos canvas, which contains no cotton, and "commercially pure" asbestos canvas which may contain from 5% to 15% of cotton carded in with the asbestos fiber. These can be distinguished by picking a piece of the yarn into fine feathery condition and touching a match to the ends of the fiber, and noting the flash and smell of burned cotton. Certain manufacturers claim that a small percentage of cotton besides facilitating the spinning and weaving into a strong pliable canvas, improves the cloth for the purpose of painting a picture upon it, as for a drop curtain, and that this small amount of cotton does not impair the fire resistance. Asbestos fibers are very slippery and difficult to card and spin, and by taking advantage of the spiral structure of the relatively few cotton fibers to bind the asbestos fibers together, the process of manufacturing a smooth canvas is greatly facilitated.

A third variety of cloth which has been highly recommended by fire chiefs and architects for a theater curtain contains very fine brass wires, 33 and 34 standard gage, woven in with the asbestos yarn. Our tests proved these fine wires to add nothing to its strength when hot. The wire used was found by analysis ⅔ copper, ⅓ zinc with a trace of lead, perhaps 2%. Probably the extreme of the wire used and the quick oxidation of volatilization of the zinc is a cause of its weakness when heated.

All of the alleged asbestos curtains that I have seen have really been of the ordinary "commercial" asbestos, and I regard the stories of painted burlap masquerading as asbestos in theater curtains as mostly idle talk.

TESTS OF ASBESTOS CANVAS.—Since our experiments on the effect of heat upon tensile strength of asbestos cloth and asbestos fiber soon disclosed that the ordinary commercial asbestos lost its strength at a heat just below redness, sufficient to drive off the combined water, in order to be sure of our ground, I had three independent series of tests upon asbestos made by three different experts. The results of all three tests proved independently that the character of asbestos cloth as to resisting a high degree of heat is utterly different from what is popularly supposed.

(1) The first series of tests were made by Prof. Chas. E. Fuller, in the Mechanical Engineering Laboratory of the Massachusetts Institute of Technology, on a special testing machine designed for measuring the strength of sail cloth, and which had been previously used in a series of tests for the U. S. Government. We had this newly fitted with double Bunsen gas burners, so arranged that a specimen could be either tested cold or tested for strength while heated to any desirable degree in either an ordinary gas flame or heated up to moderate redness in the flame of the blast lamps. These tests were made with a degree of attention to detail, which I have not space here to set forth. In brief, we found that every-one of these specimens of asbestos canvas, English and American alike, when heated for from 2 to 5 minutes to a little below redness in a common gas flame or barely to redness in the Bunsen flame, lost from 60% to 90% of its strength, and that the fiber became very brittle. We were surprised to find that the samples with the wire insertion when tested hot were no stronger than the samples without wire. On cooling they regained the little of the strength due to the wire.

(2) I desired tests on larger sheets of the canvas, more nearly reproducing conditions of use, and so the tests of our second series were made at the Underwriters' laboratory in Chicago by constructing curtains about 6 ft. square and testing them with the same furnace and apparatus that had been provided near this laboratory for testing fire shutters and fire doors. Unfortunately we found the furnace in poor working condition because of a temporary defect in the gas supply, such that we could not regulate the temperature evenly or measure it precisely. After testing several curtains we suspended these tests.

These Chicago tests fully confirm the conclusions derived from our Boston tests, that asbestos cloth is rapidly weakened by the heat of an ordinary fire to an extent that makes a curtain composed wholly of asbestos cloth an unreliable fire screen for the proscenium arch of a theater, if expected to endure more than a few minutes, and it was proved that the asbestos canvas was so weakened that it would be ruptured easily by a blow from any falling material or by a strong current of air. The seams sewed with asbestos thread showed no special weakness more than the canvas.

A notable feature in these furnace tests with fiber curtains that contained from 5% to 8% of cotton was the flame that played all over the outer face of the cloth when the furnace was lighted, and which might be distinguishing in giving for a moment an impression that the asbestos curtain was burning up.

(3) For the third series of tests the friendly services of Prof. Wm. Otis Crosby, of the Massachusetts Institute of Technology, in charge of the Department of Economic Geology, and Dr. C. H. Warren, Professor of Mineralogy in the same institution, were enlisted to examine all of the varieties of asbestiform minerals found in the extensive cabinets of the Institute of Technology and the Boston Society of Natural History, in the hope of finding specimens from some locality that possessed all the qualities properly attributed to asbestos. The result of this, in brief, was that nothing was found possessing characteristics materially different from the hydrous-Canadian fiber on the one hand, and the anhydrous fiber from Georgia on the other. The first class lost their strength at a heat which drove the water off; the second class were too stiff or brittle for spinning and weaving or occurred in quantity too small for commercial purposes.

Upon testing specimens of the Canadian fiber by heating in a platinum coil heated electrically, raising the temperature slowly, weighing the specimen repeatedly and all the time measuring the temperature in the crucible by electrical methods, it was found that a temperature up to 250° C., equivalent to 482° F., caused no driving off of the water chemically combined, and no apparent change in the pliability or strength of the fiber. A heat just below dull redness proved to be the critical point. One half hour at from 440° to 480° C., equivalent to 850° F., drove off about 3% of the combined water and made the fiber slightly more brittle than at first, with some loss of natural luster. Heated to from 630° to 650° C. for 5 minutes, averaging 1,152° F. 11% of the water is driven off, and the fiber becomes slightly brown and very brittle and crumbly.

From a series of such tests Prof. Warren concluded that a theater curtain made of chrysotile fiber alone could not be expected to hold together for more than a few moments if a temperature of 650° C., equivalent to about 1,200° F., was reached, and calls attention to the fact that being a non-conductor, the asbestos canvas would arrest and absorb the radiant heat from the burning scenery and have its own temperature rapidly raised.

In the course of sundry other tests he found independently that the brass wire inserted in certain samples of the canvas added practically nothing to their strength while hot. Chemical analyses of these wires from the various commercial samples of canvas gave copper 63% to 69%. Wires pulled out from the canvas and held in an open Bunsen flame lost their strength instantly. This led Prof. Warren to suggest that iron wire of, say, 25 or 28 gage would prove a much greater addition to the strength of curtain cloth. The residue left after driving off the water is practically infusible. Wrought iron is less readily fusible than steel, but the steel wire would probably hold up to, say, 900° C., or 1,650° F. Steel melts 1,200° to 1,300° C.; pure iron about 1,600° C. I found the small iron stairway over the Iroquois stage showed effects such as are produced by heat. Glass in the skylights was fused, which indicates about 875° to 900° C.

In other trials Prof. Warren found that a piece of asbestos canvas a foot square lost its strength so that it could be torn between the fingers after it had been held five minutes against a moderate wood fire that did not heat it to visible redness, and therefore probably not to 650° C.

STEEL PLATE PROTECTED BY ASBESTOS MATERIAL.—In our Chicago furnace tests we also experimented upon sundry combinations of asbestos, asbestos felt and asbestic cement with thin steel plate and combined with wire netting, the asbestos being placed on the stage side in the hope that it might shield the steel from the full heat and thus prevent it showing red hot on the auditorium side, while the steel would give strength. We had to suspend these tests because of some temporary trouble with the gas supply to the furnace, but they were carried far enough to prove an endurance more than ample for their purpose as a shield while an audience

ing, and it was plain to all who witnessed these ... the steel curtain protected with some asbestic ... on the fireside possessed far greater strength ... durance against fire than the simple asbestos. ... also cut off the view of the fire that was apparent ... the texture of the asbestos canvas.

... care given to the design of the guides and fasten... at edges and top so that after it was lowered the ... could not be pulled out by warping, buckling, ... explosions" or pressure of air; the steel curtains ... have value to the fire underwriter and probably ... the fire from entering the auditorium.

The general type of steel proscenium curtain finally ... in Chicago and required at all theaters was ... out somewhat hurriedly according to the average ... ment of the Aldermanic Committee in advance of any ... tests than the failure of the Iroquois curtain. It ... consists of a light framework of steel angle irons with ... rugated plate about 1/16 in. thick on the auditorium ... and some asbestic non-conducting material on the ... side, with an air space of 1, 2 or 3 ins. between. ... Where guided only by loops on vertical cables it is re... quired to lap over the edge of the arch about 8 ins. A ... structure of this kind of the ordinary size weighs from ... to 6 tons.

The hanging would be improved by more substantial ... channels to hold the edge, and by the addition of ... positive down-haul tackle or some arrangement by which ... the counterweight could be thrown off, for now the great ... weight of these curtains is so nearly counterpoised that ... conceivably the air pressure against its surface of about ... 1,000 sq. ft. may prevent the slight excess of gravity from ... lowering it.

THE FIREPROOFING OF SCENERY.

Scenes are ordinarily painted on a strong linen canvas weighing about 6.6 ozs. per sq. yd. Heavy cotton sheeting is sometimes used for the cheaper temporary productions. The gauze used for skies and transformation scenes is of cotton, of texture like mosquito netting. Frames and battens and profile backings are of white pine. The canvas is first stretched on a frame and stiffened by a coat of glue size applied warm with a broad brush. Next, it receives a priming coat of whiting and glue size and is then ready for the scene painter. The mineral colors used are mixed with water and glue, and many tests prove that the painted canvas is somewhat less readily combustible than the unpainted, and the heavier the coat of pigment the more the flame is retarded.

The fireproofing of scenery canvas and other cloths and fabrics has from time to time during the past 50 years engaged the attention of many talented men, and one who consults only the articles in books and technical pamphlets may be led to believe that this can be accomplished by brushing the surface over with either of several solutions of chemicals.

After reviewing whatever I could find in print, after consulting with several experienced scenic artists, and after making tests myself and later enlisting the friendly assistance of several experienced chemists to carry on independent investigation all solutions prominently recommended for the fireproofing of flame proofing of fabrics, I regret to conclude that the best that is possible in this line is far from satisfactory, that the petty tests that have satisfied certain distinguished chemists are very misleading as guides to what will happen when the same process is tested on the larger practical scale, and that the best we can hope to accomplish is to "flame-proof" a fabric so that it will not ignite from a match, an electric spark or a gas jet, or so that if ignited it will not burst into flame.

This much of protection is of great value and worth all that a good process costs, if it can be accomplished in practice without injury to fabric or colors, for if we can thus prevent the little flame from quickly spreading we have removed perhaps 9/10 of the danger of a fire starting on the stage, but it falls far short of what many have believed was within easy reach. Once get the gauze and canvas and pine on the stage enveloped in flame, nearly everything "fireproofed" would burn to total destruction with substantially as great a rush of flame and suffocating smoke as with the untreated material. Indeed, the chemicals may make the fumes worse.

After having investigated the question of fireproofing the scenery faithfully, I am led to believe that we must after all rely on the safeguards of the engineer rather than those of the chemist.

The efficient fireproofing of the great quantity of white pine used in frames, battens and profiles (8,000 sq. ft. in the case of the Iroquois) appears to be a practical impossibility. The 11 miles of Manila ropes cannot be "flame-proofed" without too great a sacrifice of their strength.

I have already intimated that phosphate of ammonia has given the best record in fire retardent quality of any of the many chemicals and mixtures tested. Theoretically, we should expect it to, for its chemistry fulfils the above conditions. First, it has a little tendency to gather dampness, and to dry this out absorbs a little heat. Next, as the heat rises, ammonia is given off, and the thin film of this repels the oxygen of the air. When the ammonia is gone, we have left the otho-phosphoric acid, which in liquid form covers the surface and preserves it from oxidation under increasing heat. At 300 to 400° F. this decomposes, giving off its water; at higher temperatures gives off its remaining water. In all of this dissociation it absorbs some heat until we have left at full red heat fused meta-phosphoric acid as a liquid film surrounding the fixed carbon remaining from the destructive distillation.

On the other hand, the prosphate of ammonia has its disadvantages. A manufacturing chemist, perhaps of widest experience of any in this country in the practical chemistry of the phosphates, warns me that for its best efficiency it must be applied in a strong or saturated solution, but if very strong it may in time disastrously affect the strength of the fiber, that it is somewhat deliquescent, has a tendency to develop fungous growth, that in time it may part with a portion of its ammonia, becoming the acid ammonium phosphate which has a tendency in presence of moisture to attack metals, while in a warm atmosphere the free phosphoric acid attacks some colors.

After some preliminary trials with the assistance of the chemical engineer of the Inspection Department of the Factory Mutuals and conferences with the experienced scenic artists, Burrage, of Chicago, and Story, of Boston, and after reviewing the probable effect of various solutions upon the fabrics and upon the ordinary colors used by the scenic artist with some of my personal friends who were of wide experience as chemists of textile factories and chemical works, I enlisted the constructive genius of my friend, Mr. Geo. C. Whipple, Consulting Engineer, Director of the Mt. Prospect Laboratory in Brooklyn, and of Mr. Irving W. Fay, Professor of Chemistry in the Brooklyn Polytechnic Institute, in the hope that starting with the theory of the successful action of ammonium phosphate as stated above, we could find some substance of equal value as an antipyrine that would be less likely to injure fabric or colors. Sundry theaters and scenic studies were visited by Mr. Whipple to learn the practical conditions. The bibliography of the subject was again reviewed. Standard methods for testing the comparative efficiency were worked out, and tests were made with substantially all of the substances that had been recommended by good authorities.

Nothing was found better than, or so efficient as, the phosphate of ammonia, known to be efficient for the past 50 years. Nothing was found that would prevent the instant burning with a rush of flame when the test was made with a strong blaze on closely hung sheets of canvas, but many substances were found that would make gauze and canvas proof against ignition by a match, flame, gasjet, a cigarette or an electric spark.

The general results of the investigations by Messrs. Whipple and Fay may be summed up as follows:

(1) Phosphate of ammonia was found the most efficient antipyrine.

(2) Tungstate of soda, so often found recommended in the text-books, was found to possess very small value.

(3) The various proprietary solutions when analyzed were found to be all based on one or another of the ammonium salts, commonly the phosphate but frequently the cheaper sulphate substituted in whole or in part.

(4) Linen canvas or cotton cloth, fireproofed in the best manner possible by any of these solutions could be quickly burned to total destruction if a sheet were rolled in a loose coil with the axis vertical and a space of perhaps ½ in. between the folds, and a fire then lighted with a small wad of excelsior at the bottom of the roll; this method of test serving to confine the radiant heat and the gases distilled from the fiber. This was of special interest since strips of the same cloth tested in the manner that has satisfied previous experimenters by holding the strips of treated cloth vertically over an ordinary Bunsen flame could not be ignited and appeared almost perfectly flame-proof.

(5) The most efficient part in the fireproofing of fibers was found performed by the covering of the fiber with a non-volatile liquid that excluded the oxygen. Phosphoric acid proved better for this purpose than any other substance tested, but obviously could not be applied alone, because of its corrosive action on fibers and colors.

(6) The ammonium in combination with it in phosphate of ammonia was found of value chiefly in locking up the corrosive quality of the phosphoric acid until released by the heat of the fire, and thus giving a comparatively harmless compound for application to color and fabric.

(7) The method of application of the fireproofing solution to the canvas was found to have great influence on the degree of fire protection secured. One of the best solutions, when brushed cold over the back of old scenry, penetrated the fiber so little as to be of no value, but when applied hot was efficient. Under some conditions the linen canvas is repellant of water, as one finds on trying to dry the hands on a new crash towel. When the liquid is applied rapidly to a vertical surface with a brush linen cloth does not absorb it readily. Hot application of the solution adds much to its efficient penetration of the fiber. For new scenery probably the best method is to saturate the canvas between rollers in a bath. The next best method is to mix the chemicals with the water of the glue size.

(8) Tests of the tendency of the various chemicals to induce decay were made by sowing some of the treated samples with mold spores. Other tests were made by adding various percents of phosphate of ammonia to nutrient gelatine and to mixtures of the glue size and incubating these for tests of bacterial growth.

(9) The effect of the solutions on the colors ordinarily used by the scenic artist were not found bad, except in case of some of the more delicate blues and greens, but a greater length of time would be necessary before positive statements about this can be made.

(10) When canvas that has been flame-proofed is actually burned, as it may be under practical conditions, it gives off fumes that may be even more dense and suffocating than those from the untreated canvas.

FIREPROOFING WOOD AND FIREPROOF PAINTS.

Since the pine frame work of the set pieces and wings present a greater quantity of fuel than the canvas itself, it would be desirable to flame-proof this wood. A simple brushing over with phosphate of ammonia or other chemical solutions is found inefficient.

Various processes for making wood fireproof have long been known and have been used on wood for interior finish and trim of fireproof buildings, more here in New York City than almost anywhere else, because of certain favoring clauses in the building laws. The various tests made by Prof. Norton, of the Massachusetts Institute of Technology, and others, have shown that although the wood is much less readily ignited after treatment no real fireproofing results. Previous tests have covered this matter so thoroughly and have shown the loss of strength and tendency to gather moisture and other objectionable qualities that follow treatment so that I gave little attention to testing this matter further, but rested on the tests of previous experimenters. I obtained sundry specimens of wood that had been fireproofed in the commercial way from two prominent shipyards that had war vessels under construction and made a few simple tests.

Fireproof wood was at one time much used on the war vessels of the navy, but has been almost wholly abandoned, by reason of its gathering moisture badly and the lessening of strength and the increased difficulty of working it. The frames of scenery require to be particularly light and strong, and that the wood possess its maximum strength, and that it should not be liable to warp. I soon concluded that in the present stage of the art it was too much to expect that the wood flame-proofed by any of the ordinary commercial processes would come into general use for battens, frames, profiles, etc., of stage scenery.

Fireproof paints are sometimes required by law to be applied to wood work about the stage. The underwriters' laboratory at Chicago had a short time previously made an extensive series of tests of all of the prominent ones in the market. The unpublished records were placed at my service. These tests had shown that none of these paints had any noteworthy value in flame-proofing wood, but for confirmation I requested Messrs. Fay and Norton to make tests of a few of those most prominent in the market. They purchased commercial samples and made chemical analyses of several; each was found to be mainly a sort of white-wash consisting of slaked lime, finely pulverized asbestos, with also a little alum, gypsum and glue. The paint adhered well when applied to canvas, but was quickly proved by test to have almost no flame-proofing quality whatever. It is difficult or impossible on precise scientific grounds to see how these paints can have any noteworthy value against anything but a very small blaze, like that of a match or spark.

DRY POWDER FIRE EXTINGUISHERS.

On and about the stage of the Iroquois Theater were several tubes of Kilfyre, so-called, one of the numerous dry powder fire extinguishers in a long red tube that have been so vigorously pushed into notice by enterprising salesmen during the last few years. One of the men on the stage promptly and courageously tried to extinguish the fire with this powder, and, of course, he accomplished nothing whatever, but the fact that such unreliable material was relied on there and is to-day hung up in public places where it gives a false sense of security prompts me to devote some little time to this subject.

The chief reason why these long tin tubes of dry powder have become popular is that they can be manufactured for about 10 cts. each, and that they retail as high as $3 each. They are nearly all composed of common bicarbonate of soda, frequently disguised by the admixture of a little cheap coloring matter like Venetian red and prevented from taking by the addition of starch. The party who recommended and sold these tubes of Kilfyre to the Iroquois was, I was assured, an honest man who fully believed in their efficiency, and in an effort to save others from mistakes I have had samples of everything of this kind that I could find in the

TABLE SHOWING RESULTS OF ANALYSES OF DRY POWDER FIRE EXTINGUISHERS.

Price.	Name of 8 dry powder fire extinguisher.	Percents. of Chemicals by weight. Bi-Carb. soda.	Red ocher.	Yellow Ocher (or iron ore)	Fuller's earth.	Common salt.	Amm. carb.	Sodium phosphate	Nitrate soda	Charcoal.	Fire clay	Sodium sulphate.	Fineness: Percents through sieves. 200 Mesh.	100 Mesh.	80 Mesh.
$3.00	"Kilfyre"	97.5	2.5	....	....	....	....	....	....	....	....	....	86	100	100
3.00	"Kingfyre"	96.0	4.0	....	....	....	....	....	....	....	....	....	....	....	....
3.00	Fyncide	97.4	2.6	....	....	....	....	....	....	....	....	....	75	89	87
	"Fore Dust"	99.5	0.5	....	....	....	....	....	....	....	....	....	42	65	98
3.00	"Improved"	94.8	....	5.2	....	....	....	....	....	....	....	....	82	98	99
3.00	Atomized	87.6	....	12.4	....	....	....	....	....	....	....	....	38	88	99
	Electric	95.0	....	5.0	....	....	....	....	....	....	....	....	95	98	99
0.75	Driggs	....	....	....	....	....	....	....	....	....	....	....	....	....	....
3.00	Pan-American	89.5	....	....	10.5	....	....	....	....	....	....	....	70	92	....
3.00	Phenix	30.6	....	37.9	....	7.4	2.3	8.1	....	....	....	12.9	4	54	98
3.00	"	81.2	....	4.0	....	....	....	....	....	....	14.8	....	31	94	73
3.00	Manville	82.1	....	17.9	....	....	....	....	....	....	....	....	....	....	98
3.00	"	95.5	....	1.2	....	....	....	....	2.6	0.7	....	....	26	97	....
3.00		96.0	....	4.0	....	....	....	....	....	....	....	....	....	....	98

Another series of analyses ran as follows:

		Na_2O Soda.	CO_2 Carb. acid.	Insol. matter (iron ore.)	Water in bi-carb. by diff.	Na Cl Common salt.	NH_3 Ammonia.					Na_2SO_4 Sodium sulphate.	Starch.		
$2.50	Kilfyre	35.4	50.6	4.0	10.0	....	....	....	....	....	....	....	....	....	....
.....	Monarch	....	....	....	....	....	....	....	....	....	....	....	....	....	....
3.00	Pan-American	15.3	20.3	41.1	14.1	6.7	0.4	....	....	....	....	2.0	....	....	....
1.00	Eclipse	32.6	43.2	3.4	12.0	....	....	....	....	....	....	....	....	....	....
2.00	Manville	35.0	48.0	4.0	13.0	....	....	....	....	....	....	....	8.8	....	....
3.00	Phenix	30.1	41.8	17.8	10.1	....	....	....	....	....	....	....	....	....	....

Another series:

		Bi-carb. soda.	Mono-carb. soda.	Iron oxide.	Insol. dust.	Loss at red heat.	Amm. carb.	Common salt.	Sodium sulphate.	Insol iron ore.	Water, etc.	Starch.	Clay.		
.....	Monarch	93.7	2.4	3.8	....	35.7%	....	....	....	....	....	....	....	....	....
.....	Fyricide	94.7	4.6	0.7	....	36.8%	....	....	....	....	....	....	....	....	....
.....	Pan-American	34.5	4.4	....	....	....	1.1	6.7	2.0	41.1	10.2	....	....	....	....
.....	Eclipse	87.9	....	....	....	....	....	....	....	....	....	8.8	3.3	....	....
.....	Kilfyre	96.5	....	....	3.5	....	....	....	....	....	....	....	....	....	....
.....	Swan	97.2	1.7	....	1.0	....	....	....	....	....	....	....	....	....	....

Chicago market, the Boston market and the New York market purchased in the ordinary channels of trade by different parties, and the respective groups of samples analyzed by three different chemists, in order to fortify myself against the possibility of wronging anyone through a mistake in the analysis, and have had samples sealed up and retained for further analyses should anyone question my figures. The accompanying table shows representative analyses.

The bicarbonate of soda can be purchased in quantity for about 1¾ cts. per lb. Each tube commonly contains 2½ to 3 lbs. The cost of the tin box and its gorgeous label may be enough to bring the whole up to 10 or 15 cts. If these are what one wants, why pay from $2 to $3 apiece for them? Why not buy a package of common kitchen "saleratus" at the grocer's?

I have heard remarkable stories of what extinguishers will do. Remarkable exhibitions are sometimes given under circumstances specially devised. My New York friend, the chemist, was given an exhibition by a man who poured a thin stream of benzine on the floor, lighted it and extinguished it with some of the powder. My friend was impressed, but did some experimenting at home and found that after a little practice he could do the same with either sand or salt. We had tests made of two of them by our inspectors a few years ago and found them of doubtful value on the smallest fires and worthless for a fire in free ventilation.

No doubt the material has some small value for a certain class of fires. Doubtless it is wise to carry a few tubes of this on an automobile. Doubtless, in confined situations, on the apron or inside of a cotton picker, even the bicarbonate of soda powder may sometimes do remarkably well, but it should never be used to give a full sense of security about the stage of a theater. We do not accept it in factory fire protection. We recommend they be thrown into the rubbish heap. Pails of water are far more reliable.

On the other hand, the "soda water fire extinguishers," consisting of a copper cylinder containing 2, 3 or 4 gallons of a strong solution of bicarbonate of soda, with a bottle of acid at the top so arranged that it can be upset into the soda and water, thereupon generating a strong pressure by the evolution of carbonic acid gas, are excellent for many situations where pails would be unsightly.

HAND GRENADE EXTINGUISHERS.

As shown what people will pay good money for in the effort to get fire protection, I was interested in the story that one of my agents, a chemist, brought in about hand grenades. We had purchased examples of some of the different kinds of hand grenade and had their contents analyzed. In the case of particular interest the salesman offered as proof of the superior merits of his compound the statement that a quantity had just been purchased by the United States Government for the protection of one of the battleships. Our analysis shows the contents to be simply water and common salt. I myself saw a hand grenade of the same appearance bearing the same label in the model of the battleship at the St. Louis Exposition, so perhaps it is true that the United States Government purchased salt water at 50 cts. per quart bottle for the fire protection of battleships.

The chemist reported the following analysis on certain samples of hand grenades:

Hayward hand grenade:	
Specific gravity of solution	1.188%
Common salt	22.3%
Other, solids	0.4%
Harden hand grenade:	
Common salt	18.5%
Salammoniac	6.7%
Total	25.5%
Babcock hand grenade:	
Common salt	21.2%
Chloride of calcium	6.5%
	27.7%

These materials are inert and their only advantage over plain water is that they do not freeze at ordinary winter temperatures.

FIRE ESCAPES.

Several subjects remain which we have scant time to discuss. The most important is the fire escape. I will take time only to call attention to a source of fatality that had not been foreseen until the Iroquois fire.

A type of fire escape has been developed under the Building Laws of Philadelphia primarily for use in factories, which is so remarkably efficient and so far ahead of safety of anything else that exists that we may wonder why it has not been copied in other cities. True it is somewhat expensive, but the safety it gives is well worth the extra cost.

The fundamental idea is that the stairway tower is absolutely cut off from the various rooms and floors which it serves. One must go out from the room into the open air and then enter the stairway. Once within this, he can proceed without danger to the bottom. The same idea can be applied to the fire escapes from a theater.

The great lesson out of all the theater fires as to the danger to those in the gallery should not be forgotten in designing the stairways and fire escapes. The area, the total number of stairway exits, and the total width of stairway per hundred persons, should be two or three times as great for the gallery as for the other parts of the house, and all exits should run in such a direct and obvious course that with a person once in them he could not fail to find his way to the bottom, although in total darkness. The flights of stairs should be each of the fewest steps practicable with frequent landings on which one can steady himself and with good, simple, continuous handrails that can be followed down each side and a strong center rail, continuous all the way, where wide stairs are necessary.

A sad loss of many lives occurred in the Iroquois, by reason of a blind passageway from the gallery, which led nowhere in particular, but which led out from the main exits in such a way that those rushing outward naturally took it as a line of escape. A few blindly located steps caused some to stumble; others tripped over them until there was quickly a crowded and confused mass of men, women and children caught in this cul de sac and doomed to suffocation.

As to the aisles and exits, a great deal of cutting out and enlarging of aisles and removal of seats was done immediately after the Iroquois fire, apparently without reflection that to deliver the crowd from the seats at the doorway with too great a rush increased the danger of crushing on the stairs. I question indeed whether the width of the aisles near the stage might not reasonably with advantage be made much narrower than the law now permits, thus increasing the number of good seats and the earning capacity of the house enough to pay good interest on the cost of making it safer and providing more numerous aisles, exits and stairways at the rear. The narrowest aisle permitted in a theater, even close to the stage, is commonly 30 ins. In a Pullman car and in the ordinary railway coach 22 ins. and 20 ins. is found ample for a crowd of people moving along with all necessary speed in single file.

It is far better to introduce additional aisles at the expense of making all the aisles narrower, thus lessening the tendency in a mad rush, for people to try to crowd past one another and giving better chance for those who are not strong to steady themselves by holding on with their hands to the seats on both sides the aisle as they go along toward the exit.

Another feature that is worthy of note before closing is that it is not essential for safety that a theater should stand in an open lot. Some of the worst theater fires in history have happened where the theater was open on three sides or four sides. It is far more important that attention be given to the details of fire walls and to providing passages. It should, however, always be the effort that channels of strongly arched masonry, passageways roofed almost as strongly as for a fortification, be provided running in opposite directions, so that if a fire from explosion or other unusual cause be developed in the street or along the main facade of the theater, all of the audience could easily find exit in an opposite direction to the alley or to the adjoining street.

WEEKLY INSPECTIONS.

In safeguarding our factories against fire we find systematic inspections and the filing of a weekly report one of the very best means toward safety. They would be, of equal value for the theater. A printed blank can readily be devised for each case. This should cover the completeness and operative condition of all valves, fire hose, sprinklers, fire pails, soda water extinguishers, hooks, fire doors, exit locks and latches, smoke vents, fire curtain mechanism, and particularly of the neatness, cleanliness and order of every room, passageway, closet, air chamber, loft, basement and fly gallery, used as a part of the theater building. This inspection should be made on each Monday afternoon, since the week end is the time when attractions are commonly changed and the confusion of new seats is most apparent.

A private fire brigade from the regular stage hands and ushers should be drilled regularly, the Monday drill to be a "wet drill," testing the stage hose and a few of the soda-water extinguishers, which may be turned out of the window to the area way, or into some convenient drain provided for the purpose at the rear of the stage. The head stage carpenter should always be present during a performance as chief of this brigade.

If the municipal ordinance required such reports and drills as just described, and that a duplicate of the report be filed each Monday afternoon with the public fire chief of the district, a single fireman or inspector detailed as instructor to cover all the theaters of a large city would, in my judgment, accomplish more real good than the two stage firemen required by law to be present from the public force, doing nothing in particular, at the expense of the theater, and who from my factory experience would be less efficient than the trained and responsible stage carpenter. In other words, let the law emphasize fire prevention by inspection more clearly.

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THE FIRE PROTECTION OF THEATERS.

The fire protection of theaters and places of public assembly is a matter of such vital importance and of so common neglect that no apology is demanded for the space devoted in this issue to the address of Mr. John R. Freeman, the retiring President of the American Society of Mechanical Engineers, on theater fire protection. Mr. Freeman speaks with the authority coming from a recent special study of theater fires, theater construction and theater fire protection and from many years experience as an insurance engineer, and, professionally, his utterances carry as much weight with fire protection experts as those of perhaps any engineer in this country. His presentation, the public may feel certain, is that of a trained observer and an accomplished engineer, and, while of a rather startling nature in many particulars, is, we firmly believe, not a whit more alarming than the conditions warrant. There is, indeed, no place for the alarmist in the discussion of theater fire protection, and Mr. Freeman is as well aware of this as anyone; there is, however, a place for the plain facts and these we have in plenty and to spare in the vigorous castigation administered by him to present practices in the safeguarding of theater audiences from fire.

A perusal of Mr. Freeman's address leads to two main thoughts regarding the subject with which it deals. One is that the present evil practices are to be charged to ignorance and not to indifference, the other is that structurally and mechanically these evil practices are comparatively easy to correct. Both thoughts merit attention, and the first deserves quite as careful consideration as the second though it is seldom awarded equal prominence even by engineers.

Compared with the practice of modern industrial establishments, Mr. Freeman points out, there is in theater management a general condition of carelessness and lack of foresight in guarding against fire danger. Consider, for example, the instance cited where the space from which the ventilating fans draw the air that is forced into the auditorium is used as a room to store trunks. Here we have the management through sheer thoughtlessness courting all the possibilities of a serious panic. A smudge of burning clothing of insignificant proportions would fill the auditorium with smoke and set a theaterful of people stampeding for the street. Take, further, the other instance cited where the smoke vent over the stage had been covered across with canvass to keep out drafts. Here sheer ignorance of the danger involved was responsible. It is such lack of perception of the possibilities of danger in certain commonplace things that the fire prevention expert finds the hardest to overcome of all the obstacles in the way of theater fire protection.

Passing for a moment the answer to the questions suggested in the paragraph just read, let us follow briefly the further argument of Mr. Freeman's address. A study of theater fires shows the following almost invariable sequence of events: A fire breaks out on the stage and envelops the inflammable scenery and properties with almost incredible rapidity, the curtain closing the proscenium opening between stage and auditorium fails as a barrier, the flames and hot gases sweep into the auditorium overtake the fleeing people and smother many of them, mostly in the galleries, within a few minutes after the start of the fire. The significant points to be noted are the death due to suffocation and the suddenness with which it occurs. They furnish the hints for the solution of the problem. These are the reduction of the inflammability of the scenery and provision for quenching incipient fires; an immediate and free exit from the stage of the smoke and hot gases; an immediate and efficient closing of the proscenium opening between stage and auditorium, and ample and unobstructed thoroughfares for the escape of the spectators from the auditorium. So far the paper teaches us nothing new, all of the remedies suggested are recognized, and are applied in theater construction. Why, then, we may ask, do disastrous theater fires occur? It is in his frank and complete answer to this question that Mr. Freeman's paper stands pre-eminent in the literature of theater fire protection.

By the evidence of careful and comprehensive tests and by arguments that are practically uncontrovertible the author shows that no present means for fireproofing scenery is efficient against flame of any magnitude; that the usual hand grenade and dry powder extinguishers are not equal to a bucket of water in quenching small flames; that any of the asbestos canvasses used for fireproof curtains are rapidly destroyed by moderate fire temperatures, and chief of all that smoke vents over the stage are usually too small for their purpose or else from one cause or another operate so tardily that the auditorium would be filled with suffocating vapors before a safe passage to the air was provided for them.

Taking up the details let us note first the evidence that Mr. Freeman has to offer respecting the efficiency of the various "extinguishers" and "grenades" usually employed for quenching incipient flames. These devices have been sold in untold thousands to building owners and householders who have unhesitatingly accepted the dictum that they were securing something of recognized efficiency and mysterious power in quenching fire. Mr. Freeman's tests show that the contents of the fancy tubes and bottles contain, respectively, nothing more efficient or mysterious than saleratus and plain Croton water. Now, water and saleratus may both be used with effect in putting out the start of a flame, but the first will be quite as efficient if kept in a pail and the second, as Mr. Freeman suggests, can be purchased more cheaply at a grocery store. The facts are that buckets of water stored in handy places, or, better still, frequent and handily arranged hose connections and hose are far more efficient fire fighting devices than any "extinguisher" ever invented.

Another widely heralded means of reducing the chance of theater fires is the use of "fireproofed scenery." As in the case of "extinguishers" Mr. Freeman's tests show that the supposed decrease in inflammability wrought by fireproofing solutions, paints and washes is far smaller than is commonly supposed and that "the best we can hope to accomplish is to flameproof a fabric so that it will not ignite from a match, an electric spark or a gas jet or so that, if ignited, it will not burst into flame." It must not be assumed that in this fact we have an excuse for neglecting to fireproof scenery; even the little that is gained in non-inflammability by such treatment is worth all it costs. The lesson that it is wished to teach is that fireproofing the scenery is by itself a very inadequate protection against fire.

Turning now to the question of fireproof curtains for closing the proscenium opening we have again an illustration of the frailty of the supports on which theater goers place their dependence of safety from fire. Mr. Freeman's tests show that asbestos cloth of any of the qualities to be obtained in the market is rapidly weakened by the heat of an ordinary fire to an extent which makes a curtain composed wholly of it an unreliable fire screen if expected to endure more than a few minutes. The special cloths into which wire is woven to give greater strength proved in the tests to be scarcely better than the plain fabric. The readers of Engineering News will remember the failure of the Iroquois Theater curtain in the appalling disaster of two years ago, a failure so complete that it was for some time thought that the material was ordinary canvas and not asbestos cloth at all. Mr. Freeman points out that as a matter of fact the material of this curtain was good quality asbestos cloth, quite as perfect as is used in any modern theater. The only reliable fire stop for closing the proscenium opening, Mr. Freeman concludes, is a sheet steel curtain, asbestos covered if desired, which is strongly hung, firmly guided at the sides, sufficiently tight fitting to stop the passage of gases in volume and so designed in respect to its operating mechanism as to drop into place quickly and certainly in case of fire.

The most important of the protection devices cited, namely smoke vents over the stage, have been left for consideration until the last. In practically all of our large cities such smoke vents are required by ordinance. Practically all metropolitan theaters are provided with such means of egress for the gases of combustion. In his study of theater construction Mr. Freeman finds, however, much to criticize in smoke vent design, construction and operation. Very often the area of the vent is smaller than good practice demands. In all cases the means provided to insure the immediate automatic opening of the vent in case of fire is slow and uncertain. In numerous cases the vent doors or shutters have been so long left without care that they can hardly be operated even with men and tools. The significance of such conditions need not be dwelt on; the remedy is equally plain and is thoroughly discussed in Mr. Freeman's paper. The important thing to be noted here is that the cardinal principle of theater fire protection is the immediate and complete expulsion of the smoke and gases of combustion to the outside air from the stage space.

We have now reviewed the several means available for rendering theaters safe from fire, have considered their relative importance and efficiency and have observed the suggestions made for improvement. However well we guard against the occurrence of fire and provide for its confinement to such a space and for such a time that the audience can safely escape from the building, the problem of theater fire protection is not solved until efficient and reliable means are provided for quenching the flames when they occur.

At present the usual means for performing this essential task are building hose supplemented by a more or less complete equipment of "fire extinguishers." The main reliance is the city fire department. Mr. Freeman, speaking from the teachings of his long experience in factory fire protection, considers that the best possible device would be a complete sprinkler installation. For the arguments advanced in support of this contention the reader is referred to the paper printed elsewhere in this issue. It may be noted, however, that there appears to be no good reason why sprinklers could not be applied to theaters quite as well as to factories or why they should not prove fully as successful in one place as they have in the other.

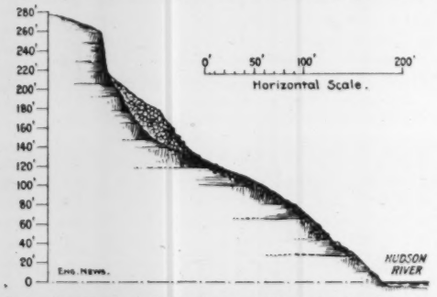
Summarized in a few sentences the argument presented is: Provide adequate means for the escape of the gases of combustion and for closing the proscenium opening; supplement these with scenery treated with phosphate of ammonia to make it so far as is possible non-inflammable, or more correctly, slow to ignite into flame, and, finally, provide a complete automatic sprinkler equipment for quenching any fire that may get beyond the control of the stage hands with water

buckets. These are methods and devices all easy of provision and application if a little expert study be given them and a little of the money now spent for extra ornate decoration be diverted to the task of making human life safe.

A feature of Mr. Freeman's paper which should receive particular attention, however, is his demonstration that no safety device and no combination of such devices however well designed and efficient it may be will perform its intended function unless it is maintained in constant and perfect working order. A necessary provision in the fire protection of theaters is therefore a system of thorough inspection of all safety devices, and particularly of the working condition of the smoke vents and the proscenium curtain. Such inspection to be thorough should involve the actual operation of the curtain and the smoke vent shutters often enough to place beyond doubt the perfection of their operating conditions.

It is a comparatively simple matter to analyze the problem of theater fire protection and it is not a very difficult matter to devise reasonably efficient safeguards against the chief dangers that are found to exist, but how are we to bring about the better conditions that are possible? A full answer to this question is too ambitious a task to be undertaken here. Mr. Freeman himself does scarcely more than indicate the problem and advance rather tentatively the suggestion that something like the comprehensive inspection systems of the various New England mutual factory insurance associations would be provocative of gradual improvement. Doubtless the solution lies along some such line of publicity and educational training but what the detail of procedure should be cannot be stated without more labor and thought than can be devoted to the problem in a hasty examination.

The huge excavation for the Panama Canal across the Culebra divide will be by far the greatest furrow in the earth's surface ever made by human agency. It is so large that the mind fails to grasp its real magnitude and it can only be appreciated by comparison with some familiar object. To aid our readers in forming an adequate conception of this part of the task which the United States has undertaken at Panama, we have drawn two average cross-sections of the Culebra cut and present them herewith.



Cross-Section of Palisades on West Bank of Hudson River at Fort Lee, N. J., Opposite 164th St., New York City, Drawn to Same Scale as Cross-Section of Culebra Cut.

A word of explanation is needed as to what we mean by average cross-sections. The maximum original elevation of the ground surface at Culebra was 345 ft. above sea level; but we have chosen not this maximum elevation, but the average height of the Culebra hill for a distance along the canal line of about *five miles*. The upper cross-section shows the cut necessary for a lock canal with an elevation of about 85 ft. above sea level. This was the level recommended by the Isthmian Canal Commission of 1901, and is about the level on which, from present indications, the canal is likely to be constructed.

The lower cross-section shows the cut necessary for a sea-level canal of the same dimensions. To give an idea of the immense proportions of the sea level cutting we have shown several objects in the canal and on the berme beside it. First is shown a cross-section of the Great Northern steamship "Minnesota," which ranks with the half-dozen largest vessels afloat. This vessel is so huge, however, that it rather tends to dwarf the canal excavation. A much better idea of the huge cutting is afforded by the large steam shovel and locomotive shown on the opposite banks of the canal.

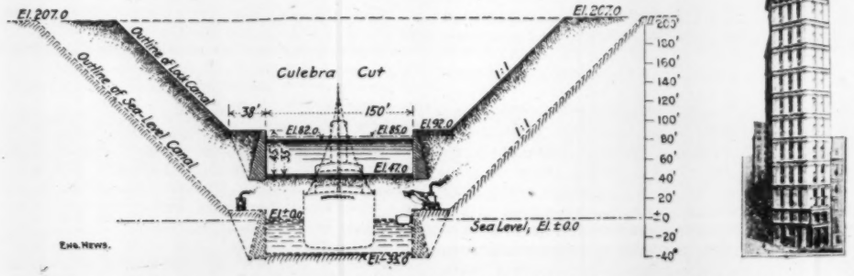
An interesting comparison between the depth required for a sea-level canal cut and the height of a sky-scraper office building is also here shown. A view of the St. Paul Building, in which are located the offices of Engineering News, has been reduced to the same scale as the drawing of the canal cross-section. This suggests the idea that if the reader will stand at a window of some tall office building at a height of about 250 ft. and look at some object at about an equal distance from the base of the building, he can readily appreciate how deep the sea-level canal cutting would look to an observer standing on its banks before the water is turned in.

But the most instructive comparison of all, to our minds, is that between the Palisades on the west bank of the Hudson River at Fort Lee, N. J., and the canal cross-section. Of course, farther up the river the Palisades are much higher, reaching an elevation of about 600 ft., but at Fort Lee, as shown by our cross-section, they are very little higher than the top of the Culebra cut would be above the bottom of a sea-level canal excavation. In other words, an artificial valley must be dug for five miles at Panama (if the sea-level plan is adopted) which will be in depth (though not in width) something like the natural chasm occupied by the Hudson River as seen by the dwellers on the upper part of Manhattan Island. Such a comparison is surely calculated to impress one with the size of this portion of the task we have undertaken at Panama. It enables one to better appreciate, moreover, the force of some of the arguments against the sea-level plan brought forward by Mr. Wm. H. Hall elsewhere in this issue.

A question of considerable interest, recently raised by a correspondent, relates to the largest existing artificial excavation which is at all comparable with the Culebra cut. Great amounts of excavation were done, of course, on such works as the North Sea Canal, the Manchester Canal and the Suez Canal; but all these were built through comparatively level country.

So far as we are able to find, the only deep cut at all comparable with that to be made through the Culebra divide is the great Nochistongo cut through the hills which surround the valley of Mexico. This huge excavation was begun in 1640 for the purpose of affording an outlet to the flood waters which had inundated the City of Mexico, and destroyed a great part of the city and its inhabitants. For more than a hundred and forty years, labor on this great work was the chief task of the Mexican nation, and it was not until the year 1789 that it was finally completed. The total length of the Nochistongo cut is 2½ miles. Its greatest depth is 197 ft., and its greatest width 361 ft. The total amount of material excavated was about 54,000,000 cu. yds. In comparison with this, the cut at Culebra will have a considerably greater maximum depth and width, even for the project with the 85-ft. summit level. The total cube of excavation at the Culebra divide was estimated by Mr. John F. Wallace at 185,000,000 cu. yds. for the sea-level canal and 111,000,000 cu. yds. for a canal with a 60-ft. summit level.

While in mere size of excavation the cut through the Panama divide is by far larger, the fact that the Nochistongo cut was made with absolutely no aid from machinery or mechanical power but wholly with human muscle, makes our task on the Isthmus seem like mere child's play in comparison with that accomplished by those patient toilers under the torrid sun of Mexico two centuries ago. When one recalls that this deep artificial valley, more than 12 miles long, was all dug by the labor of Indians, who excavated the material with the crudest hand tools and carried it in baskets on their heads to the place of final deposit, the great cut of Nochistongo* is entitled to rank with the Pyramids of Egypt, among the world's greatest wonders.



CROSS-SECTION OF CUTTING THROUGH CULEBRA DIVIDE ON THE PANAMA CANAL.

Height of surface is taken as 207 ft. above mean sea-level, which is the approximate average height for a distance of five miles. (See profile.)

Full Lines show Summit Level of Lock Canal with water surface 85 ft. above mean sea level as Recommended by Isthmian Canal Commission of 1901.

Broken Lines show Section of Sea-Level Canal Recommended by Engineering Committee of Panama Canal Commission in February, 1905.

Scale is shown by a Cross-Section of the Great Northern Steamship "Minnesota" of 21,000 tons register, one of the largest steamships in the world. On the left berme is a large freight locomotive and on the right berme is a 40-ton steam shovel in position to dump into a scow of about 15 ft. beam.

Beside the Cross-Section of the Canal there is shown on the same scale a view of the 25-story St. Paul Building, No 220 Broadway, New York City, 313 ft. high above the street level. The base of the building is on a line with the bottom of the sea-level canal.

While in mere size of excavation the cut through the Panama divide is by far larger, the fact that the Nochistongo cut was made with absolutely no aid from machinery or mechanical power but wholly with human muscle, makes our task on the Isthmus seem like mere child's play in comparison with that accomplished by those patient toilers under the torrid sun of Mexico two centuries ago. When one recalls that this deep artificial valley, more than 12 miles long, was all dug by the labor of Indians, who excavated the material with the crudest hand tools and carried it in baskets on their heads to the place of final deposit, the great cut of Nochistongo* is entitled to rank with the Pyramids of Egypt, among the world's greatest wonders.

*For published descriptions of the great Nochistongo cut reference may be made to Engineering News of April 5 and 12, 1890, and Trans. Am. Soc. C. E., Vol. XII, p. 163.

LETTERS TO THE EDITOR.

Questions on Burning or Overheating of Rivets.

Sir: In reference to Mr. Henning's discussion of burnt rivets in Engineering News of Nov. 16 I desire to ask:

(1) Have actual experiments shown that steel and wrought iron, such as is used in rivets, are materially injured by being heated several times, but not above a straw-colored heat? If so what are the signs of injury?

(2) Do not many reputable and experienced bridge engineers and inspectors of New York city accept rivets that are heated till they show signs of sparking?

(3) Authorities differ in reference to the acceptance or rejection of rivets that are slightly pitted. Such rivets were accepted by engineers in charge of important portions of the New York Subway, and by inspectors on U. S. Government buildings. Who shall decide the question?

(4) There is a wide difference between the rules of book and magazine writers and the actual practice on a great deal of so-called first-class work. Are not many reputable engineers willing to allow in actual practice methods of heating rivets that they are not willing to acknowledge in print?

A Subscriber.

Corry, Pa., Nov. 25, 1905.

The Use in Bridges of Eye-Bars Made by the Springer and the Strobel Processes.

Sir: In your issue of Nov. 30 you published two letters relating to "Development of Eye-Bar Manufacture," one by Mr. C. P. Buchanan and the other by J. H. Springer, Sr. In view of the fact that my name is mentioned by

(to latter and his letter gives Table II. as tests of steel eye-bars, I desire to correct the impression given thereby that any such bars were used in bridges.

Mr. Buchanan's statements are correct and based on his records; and my records and presence at the Keystone Works at the time permits me to speak from personal knowledge. No steel eye-bars were made by the Springer or Strobel methods which were used in bridges; these methods were used for iron bars in bridges.

Permit me to corroborate the statements of Mr. C. L. Strobel at p. 579. All eye-bars of steel and used in bridges were made by upsetting the ends of bars and then die-forging them into heads, afterward annealing them to remove the effects of local heating and working. Neither the Springer nor Strobel methods can be considered "developments in manufacture of eye-bars," as they were never introduced and continued in any shop.

Yours truly, Gus. C. Henning.

150 Nassau St., New York, N. Y., Dec. 1, 1905.

The Right or Left Fork of a Stream.

Sir: During the past year I have had occasion to map all of the eastern part of the state of Kentucky and have noted the prevailing custom in naming forks of streams "right" or "left." In much of this territory the only roads are either in the beds of the streams, or along their banks, and so the analogy between the forks of a stream and the forks of a road is close. The fork is more apparent to one approaching it along the main stream or road than it would be to one going in an opposite direction along one of the branches. Perhaps for this reason the universal custom is to designate as the right fork that on the right hand in going toward the source of the stream. Yours,

John P. Brooks.

Lexington, Ky., Dec. 6, 1905.

Sir: With reference to a recent inquiry in your paper as to what constitutes the right or left "fork" of a stream, the writer wishes to say that recently he was engaged on some work in Texas which required the retracing of a large number of old descriptions.

Several of these referred to the right or left "fork" of a stream, and in all cases we proceeded as if we were *ascending* the stream; we had occasion to go over most of these descriptions with a competent county surveyor, and he did not hesitate to accept the descriptions as referring to a person ascending the stream.

During the same work we found several descriptions reading the right or left 'bank" of a stream, and in all cases these were taken to mean as you descended the stream.

Probably no difference of opinion exists as to what constitutes the right or left "side" or "bank" of a stream, and it seems to the writer that it would be in many cases impossible for a surveyor to designate the right or left "fork" of a stream unless he were ascending it, and had reached the point where it divided.

No doubt the term is an old one, used only in the early days of surveying, as the deeds referred to which carried such descriptions were all very old ones.

Respectfully,

Wm. H. Kimball, Assoc. M. Am. Soc. C. E.

Davenport, Ia., Dec. 4, 1905.

Sir: It is true, as Mr. F. Hodgman says, that north, south, east and west are usually given to designate the various branches which fork out from the main stream, but I find right and left are frequently used in certain sections of the country. For instance, in looking over several atlas sheets of West Virginia, surveyed by the U. S. Geological Survey, I found right fork and left fork used in a number of places to name the branches. In every case, *right* was used to designate the branch on the right hand when facing upstream. It seems to me that this naming is the correct one, because "to fork" is usually accepted as separating or dividing. Webster gives one definition for "fork" as follows: "To divide into two or more branches; as, a road, a tree, or a stream forks."

One would naturally think of a stream forking as referring to the various branches spreading out as one looks or journeys towards its source, and it is reasonable to suppose that a branch on the right hand would be called the right fork, and one on the left hand, the left fork.

I quite agree with Mr. B. P. Thomas, that the reverse of the rule of naming the banks applies to naming the forks. Very respectfully,

J. H. Wheat.

U. S. Geological Survey, Washington, D. C., Dec. 8, 1905.

Sir: Referring to my previous inquiry regarding the right and left bank of a stream, and the right and left fork of a stream, which inquiry has called forth so many evidences of interest in the question, would say further that since the time this question first came up, upon which occasion I was called to testify concerning the matter in a legal action, I have taken pains to make an extended examination of the county records in a majority of the mountain counties of the states of West Virginia, Virginia, Kentucky, Tennessee and North Carolina, and in each of these places I find an almost unanimous uniformity in the description of various tracts (whose locations I know definitely) as lying on the right or left bank of various streams, when going up-stream.

I am fully cognizant of the authorities which Mr. Hodgman so courteously quotes, yet were an engineer to follow such authorities in the location of patented or early surveyed lands in the territory mentioned, he would soon find that the evident purport of the descriptions was exactly opposite.

In the case of the forks of a stream, I believe the majority of engineers consider these to be named in the opposite direction to the banks (vide reply of B. P. T., Engineering News, Nov. 30, 1905). The question is one of grave concern to those of the profession who are called upon to deal with it in this section, where nearly every survey is followed by a law suit.

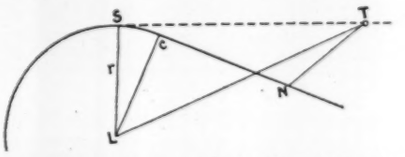
Very truly yours,

Henry M. Payne.

Williamson, Mingo Co., W. Va., Dec. 9, 1905.

A Problem in Railway Location.

Sir: The problem of locating a tangent to two located curves (W. W. Urquhart, Oct. 26, 1905; R. W. Gay, Nov. 16, 1905) suggests the old puzzler: To throw a tangent from a given curve to pass through a given point. The traverse method makes this a very simple problem; never having seen it in print I herewith outline the solution.



In the sketch are shown a curve and a point T; a tangent is to be run from the curve to pass through T. The point T is tied to the curve by a random line, as, for instance, a tangent C N and a course N T. Solve this traverse, in this case L C N T, for the latitude and departure of T as referred to L. and thence compute the length and bearing of line L T. Then solve the right triangle L S T, of which L S is the known radius, S is a right angle, and L T has just been found. From this find the distance on the curve from C to S, by subtracting the bearing of S T (or S L) from the bearing of C N (or C L), and running the angle so found backward from C to get S. W. N. Frickstad.

Stillwater, Minn., Nov. 20, 1905.

Locating a Railway in the Northern Ontario Wilderness.

Sir: From my home at Hermanville, P. E. I., to Omawabanash, in the northwest confines of Ontario, Lat. 50° 20′, is a far cry. A little over a month ago a telegram brought me to Ottawa to take a position on the Transcontinental Railway survey with a party in the extreme northwestern part of Ontario. On Monday night I left with a number of our party for Nipigon, Ontario, a small town on the C. P. Ry., 1,000 miles west of Ottawa, which is the base of supplies for several of the surveying parties. This town is also the headquarters of District Engineer Perry and Assistant Engineer Harrington. Here we tarried about two weeks, getting the party together and accumulating the outfit. As the line is some 180 miles north of Nipigon, and the journey to it is performed wholly by canoe, one may readily conceive that the outfitting for such a journey was of no small importance.

On July 4, however, we were ready to make the start up the Nipigon River. Our party consisted of 25 men, including 6 Indians, with pack-sacks, instruments and a week's provision—enough to reach the first cache at the head of Lake Nipigon. Our journey involved 40 miles up the Nipigon River, 60 miles across Lake Nipigon, and 60 to 80 miles by lake and portage to the Line. We had five large 20-ft. canoes carrying four men, and two small ones carrying three and two men, respectively, besides pack-sacks and provisions, seven tents, surveying outfit, etc. Twenty miles from Nipigon we reached the first portage, two miles long. Here a team of horses was at hand to haul our outfit. At the next portage, a few miles further up the river, two men carried each canoe across the portage, and every man in the gang helped to carry across the outfit. The Indians, who were used to this work, set the pace, and at first it was no small wonder to us to see the loads those Indians would carry across the portage; 200 pounds was a common load for them. After some experience, however, our own white men would take loads almost equal to the Indians. On reaching Lake Nipigon we had plain sailing for two or three days, except when it was blowing too hard to venture on the lake. Lake Nipigon is full of islands, there being not more than 6 or 7 miles of open water between any of the islands, by the route we took. By this time our larder was getting low, our stock of bread ran out, and the cook had to bake "bannock" on a reflector by the camp fire. For about ten days, or until we reached the location for the survey, our bread was confined to bannock.

On Saturday evening, July 8, we reached Nipigon House, near the head of Lake Nipigon, a Hudson Bay Post, where we camped over Sunday. At noon on Monday we reached the first cache of the Transcontinental Ry., at the head of Lake Nipigon. Here we refitted, taking a month's provisions, as well as materials for building a cache at our destination. Our seven canoes were now heavily loaded, and portaging became serious work, particularly as there were 27 portages to make before arriving at our destination. Some days we would make as many as seven portages, some of them half a mile long. This meant from four to five trips across the portage for each man in the party. It was surprising how proficient we all got in the use of the pack-strap. On July 17 we finally reached our destination here, having been 13 days on the journey from Nipigon station. Our first task was to build a cache, with no tools except our axes and no materials save a few pounds of spikes and the green forest. All hands got to work, some chopping, some carrying logs, and the more experienced putting up the shack. It was built entirely of round logs, the floor and roof of poles and the chinks filled with moss. Next we had to erect a small shack for the cachemen, of the same material. The crude building was strong, and fairly comfortable. The caches and warehouse are kept filled with provisions and outfit, and transport men are all the time engaged in bringing forward the goods from Nipigon, so that there is always a well filled cache reasonably near the place of operations on the survey. J. A. Macdonald.

Omawabanash, N. W. Ont., July 23, 1905.

P. O. Address, Nipigon, Ont., Party No. 1, July 23, 1905

Notes and Queries.

T. I. S., Ancon, Canal Zone, writes:

Please advise me how a young engineer can obtain the publications of the American Society of Civil Engineers and the various State Engineering Society Reports. Is it necessary to hold membership in each society, or are the publications on sale?

All engineering societies, so far as we are aware, sell copies of their published transactions to outsiders not members. Prices and terms can be ascertained by addressing the secretaries of the several societies.

THE INTERNAL COMBUSTION ENGINE AS THE PRIME MOVER OF THE FUTURE.*

By C. E. Sargent.†

The theoretical and practical efficiency of the internal-combustion engine is from two to five times greater than that of the average externally-fired heat engine. The smallest gas engines have a thermal efficiency of 20 to 24%, while the largest steam engine, with all modern refinements, does remarkably well to turn into work 12% of the heat supplied to the furnace under normal conditions. A plant recently tested by the writer, in which producer gas from anthracite culm was used, showed the cost of fuel to be 1.5 mills per HP.-hour, and it has been claimed that by selling the by-products of the bituminous gas producer at the market price, power from gas engines can be generated 14% cheaper than that from waterfalls.

The first cost of a large gas engine plant (including producers, coal-handling apparatus, piping, scrubbers, cleaners, building, compressor and engines) is not far from that of a steam plant (boilers, engines, pumps, condensers, chimney, piping and all accessories). As great pressures are not maintained in the former, the depreciation from internal strains and corrosion should be considerably less, and gas engines do not wear out more rapidly or need more repairs than steam engines. Gas producers are long-lived apparatus, requiring but little attention and few repairs. The Erie Ry. has had two producers in operation at Jersey City for seven years, and in one of these the fire has never been out. The stand-by losses are much less in the gas engine plant if run intermittently or if part of the equipment is held in reserve for immediate service. The gasholder with the producer provides for the peak of the load, even though the producer is run at a uniform rate. When compressed air is available, and all large units use this medium, gas engines of any size can be started and can take the full load in two minutes, as no warming or draining of the cylinder is required.

If the internal-combustion engine has so many advantages over steam, why has it not had a greater development. Why are we burning 400 ft. of waste gas under our boilers to evaporate sufficient water for 1 HP.-hour, when 100 ft. burned behind the piston would do the same work. Because the American manufacturers have not kept pace with the development of the gas engine as a prime mover. Five years ago, when Mr. Henry Wehrum

*Abstract of a paper read at the meeting of the Western Society of Engineers, Chicago, Dec. 6, 1905.

†Sargent Engineering Co., 1325 First National Bank Building, Chicago.

wanted gas engines of 1,000 and 2,000 HP. for the Lackawanna Steel Co.'s new plant at Buffalo, there was practically but one engine available, and that of foreign make. But a few months ago, when the Carnegie Co. wanted engines of the same size for the Edgar-Thompson works, 12 proposals were received from American manufacturers. And the largest engine ever built is a twin-tandem, 52 × 60 ins., of 5,400 brake HP., now being erected for the California Gas & Electric Corporation; three others of the same size will follow. (Engineering News, Sept. 14, 1905.)

These 5,400 HP. engines were built by the Snow Steam Pump Works, which has built 25 internal-combustion engines, aggregating 48,000 HP. Four compressors of 1,000 HP., built by this firm, are in use at Lancaster, O., burning natural gas for fuel and compressing gas to 30 atmospheres for pipe-line transmission. The De La Vergne Machine Co. has built nearly 50,000 HP. of two-cycle and four-cycle gas engines, and has 40,000 HP. installed at the Buffalo plant of the Lackawanna Steel Co.; this is the largest installation in the United States and consists of Koerting engines running on blast-furnace gas.

The Allis-Chalmers Co. builds an American edition of Nurnberg engine; this is a double-acting tandem engine, governed by reducing the gas and increasing the air, varying the proportions but keeping the compression constant. The Wellman-Seaver-Morgan Co. is now manufacturing the Cockerill engine to run on blast furnace gas, and the Power & Mining Machinery Co. manufactures the Crossley engine having cylinders on opposite sides of the crank shaft. The Westinghouse Co. builds vertical engines up to 650 HP. and horizontal engines from 200 to 3,000 HP., if not larger; it is installing engines of 2,000 HP. The largest vertical single-acting gas engines ever built are those of 800 HP. built by the Struthers-Wells Co.; they have four cylinders and with anthracite culm and gas producers have delivered 1 brake-HP. at 1.5 mills per hour for fuel. There are at least half a dozen manufacturers in this country who will take contracts for engines of any size.

The beginning of the gas engine era in the United States dates practically from the expiration of Dr. Otto's fundamental four-cycle patent in 1890, and there are several reasons why the owners of the American rights did not make more progress while they enjoyed the exclusive monopoly. One of these is that only illuminating gas was available, and this cost more than it does now, so that with a very high priced engine the advantages of the internal combustion engine over steam were questionable. But when it was found that the by-products of the refinery, gasoline and distillate were available for fuel, and the fundamental patent had expired, manufacturers who had been experimenting with other types began to build Otto engines. To-day there are over 800 manufacturers of gas engines in this country. The opening of natural gas wells and the invention of practical gas producers have provided cheap fuel, and the utilization of gas from coke ovens and blast furnaces has given the present impetus to the industry.

When the work done by the engine required no such niceties of regulation as in driving dynamos or textile machinery a single cylinder engine with an impetus at every other revolution when loaded or once in a while when light, was satisfactory. But with the necessity of a better turning moment and better governing, more cylinders were added (increasing the impulses per revolution) or the admission was throttled (reducing the mean effective pressure of each revolution). As the highest possible compression without danger of premature ignition is conducive to the highest efficiency, the former, or "hit-and-miss," method of governing is more economical than reducing the charge. But the advisability of a close regulation and uniform rotation make the latter method imperative. Natural gas can be compressed to 150 lbs., alcohol vapor to 190 lbs., and blast furnace gas to 210 lbs., and still require an electric spark for ignition.

The exhaust stroke of a four-cycle single-acting engine has no compression to bring the reciprocating parts to rest, but a triple or quadruple crank is not only expensive but the work on one crank must be transmitted through the others. There arose a demand, therefore, for a double-acting engine which, if made tandem, even with the four cycle, would not only give two impulses during a revolution but would bring the reciprocating parts to rest by the compression. A 60-HP. engine embodying these features was designed in 1897, and was, to my knowledge, the first successful double-acting engine ever built, although Dick, Kerr & Co., of Scotland, had built a few four-cycle and six-cycle tandem engines.

With a single crank tandem construction we get as many impulses as with a single cylinder steam engine; and a twin tandem gas engine gives as many impulses as a cross-compound steam engine. With these gas engines the driving of multiphase generators in parallel is readily accomplished. To utilize the heat and pressure in the exhaust, compound gas engines have been suggested and tried, and in some cases have shown an increased efficiency.

There is a limit to the degree of expansion desirable, for when the pressure equals the force required to overcome the friction a further expansion reduces the efficiency of the engine. For this reason an engine decreases in efficiency as the load gets lighter. In a single-expansion steam engine it has been found that a terminal pressure of about 4 lbs. above that of the atmosphere is the most efficient pressure of release. On account of the lower mechanical efficiency of the gas engine a terminal pressure of 6 to 8 lbs. seems to give the greatest economy. The greatest heat corresponds to the greatest pressure, and the cylinder surface increases so rapidly as the piston advances that the flame is cooled down as fast as it is propagated. This causes a loss of efficiency which is overcome in engines advancing the time of ignition with the cut-off.

Steam turbines, reciprocating steam engines and waterwheels have their place, but the internal combustion engine is destined to be the prime mover of the future.

Besides the several designs of gas engines noted in the above paper, brief reference was made to Mr. Sargent's own engine, which is built by the Wellman-Seaver-Morgan Co., but which is quite a newcomer in the field. It is a double-acting tandem engine, and has the following specially important features: (1) Expansion of the burning charge to practically atmospheric pressure; (2) variation of the point of cut-off of the admission inlet with the load; and (3) advancing the time of ignition as the mixture gets weaker and the combustion slower. The advantages claimed over other engines are higher efficiency, greater regularity of speed, and smooth running under early cut-off. The normal cut-off at full load is from 62.5 to 75%, and the exhaust is a little above atmospheric pressure, with a corresponding temperature of about 400° F. As the load increases or decreases the governor varies the point of cut-off, as in a steam engine.

THE GAGING OF STREAMS BY CHEMICAL MEANS.

By W. L. Butcher, Assoc. M. Am. Soc. C. E.*

Although gaging the flow of streams by chemical means cannot supplant ordinary methods of stream gaging it has a distinct field of usefulness. It may be used for the measurement of flows at times when it is impracticable or impossible to employ the weir, float or meter. It should be of use, also, for the rating of large weirs or dams, as great accuracy may be obtained when refined chemical methods are utilized.

Stromeyer,† in England, who has investigated the subject and experimented with English rivers, has come to the conclusion that by this method flows correct to within 1% may be obtained.

The method consists of pouring, at a uniform rate, into the stream to be measured, a chemical, for which very sensitive reagents are known. Samples are then collected above and below the point of introduction of the solution and the amount of the added ingredient in the lower sample determined. The discharge may then be computed, as the ratio of the flow of the solution to the flow of the stream is, of course, the same as that of the percentage of added salt to the percentage in the solution.

If possible, the solution is introduced into the stream above a cataract, dam or some obstruction which will cause a thorough mixing with the water. The lower sample, which is collected at a point far enough down stream, and in such a manner as to insure a good average of the water passing, succeeds the upper one by the estimated time that it takes for the water passing the upper to reach the lower station. In this way errors due to fluctuating amounts of the salt originally in the water are eliminated. Stromeyer, although he experimented with a number of substances, used for the most part in his work a solution of common salt. For large rivers he recommends sulphuric acid. The use of salt in a stream liable to pollution is objectionable for the reason that it is difficult to eliminate errors due to a changing amount of salt contributed by the polluting matter.

While seeking for some practical "field method," along the lines of the above experiments, which would not require the time or skill necessary for making the analyses required, the writer was impressed with the possibilities of some of the Aniline Dyes. It is a well-known fact that these dyes are discernible in very dilute solutions. The late found that Fluorecein, when viewed through a Fluoroscope, which was simply a glass tube three or four feet long and closed with a rubber stopper, could be detected in dilutions of one part in two billion parts of water. Fluorecein, however, is of little value for gaging purposes, as it is not soluble in water and but slightly so in alcohol; thus large and expensive solutions would be required.

A trial of various dyes showed that Eosin, which is soluble in water, would give satisfaction. It

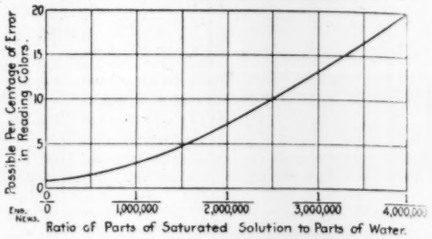


Fig. 1. Curve Illustrating the Gaging of Streams by Chemical Means.

the use of white glass tubes about 1 ft. long and ¾-in. in diameter, similar to those used for comparing colors in water analysis, it was found possible to distinguish between the colors due to varying percentages of dye in different tubes and with different degrees of dilution, as shown approximately by the diagram, Fig. 1.

As Eosin is one of the Fluorescent type of dyes, colors may be compared, either by reflected light, by looking downward into the tube placed vertically on a black background, or by transmitted light, in which case the tube may be held above a white sheet of paper on a table. In general, it will be found that when the dilution is not too great, colors may best be compared by reflected light; but when the percentage of dye in the water is very small, transmitted light will be the more serviceable.

From the diagram it will be seen that if we desire, perhaps, to measure, with an error of not more than 5% or 6%, the flow of a stream which has an estimated discharge of 1,000 cu. ft. per sec., about six gallons of saturated solution would be required, in order to maintain a proper rate during the half hour or so necessary for the determination. This later element depends, of course, upon the location of the gaging station. If conditions are favorable for a quick and thorough mixing of the solution and water, the distance between stations, as well as the length of time during which the flow of solution must be maintained, may be a minimum.

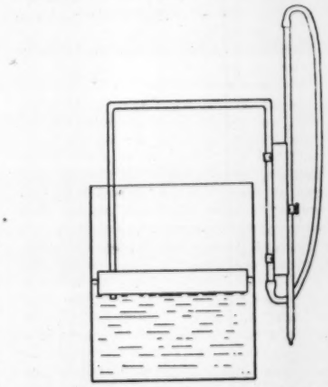


Fig. 2. Device for Dosing With Chemical a Stream Which is to be Gaged.

As the success of the method depends largely upon a knowledge of the exact rate of flow of solution, apparatus must be used which will insure a uniform and known supply. For this purpose, the device sketched in Fig. 2 will be found useful. In a receptacle for holding the solution

*211 Lake View Ave., Cambridge, Mass.
†Proceedings, Institution of Civil Engineers, Vol. CLX.

is a float that supports a glass siphon. Just above the open end of this siphon is fastened a small block of wood, having a shallow vertical groove in its outer side. This groove forms a guide for a glass tube which may be clamped with its open end at any desired depth below the level of the surface of the liquid, and which is connected to the siphon by a piece of rubber tubing. This arrangement allows the rate of flow of the solution to be regulated within certain limits. The actual rate should be calculated whenever a measurement is made, by observing the fall of liquid in the receptacle, during a certain length of time, as air bubbles in the upper parts of the apparatus may, with equal heads, cause the rate of flow to differ slightly at different times.

The details of making a measurement are as follows: After selecting a station and collecting samples as indicated above, standards, with which to compare the diluted solution, are made by placing known amounts of the original solution in different portions of the sample of water collected above the point of introduction of the dye. In order to obtain the rate of flow of the stream, it is then only necessary to multiply the rate of flow of the solution by the number of times it has been found to be diluted.

For the person occasionally called upon to gage the flow of a stream and to whom a meter is unavailable the above method provides a satisfactory means.

TESTS OF THE PLUNGER ELEVATOR PLANT IN THE TRINITY BUILDING, NEW YORK CITY.*

By Arthur J. Herschmann,† M. Am. Soc. M. E.

The tests to which the appended tables refer are commercial tests made while the plant of the Trinity Building was in regular operation. It was not thought that the accuracy of the results would have been materially improved by resorting to greater elaboration in preparing for the test, or in the manner of conducting same. On the other hand, it was held that with the adopted plan data would be obtained which could be more readily compared with other buildings in regular operation and which should, on account of the peculiarity of elevator service in an office building, more correctly define actual economy than data which would result from a dead load test in which intermittency of service would not be portrayed.

It will be seen that two series of tests are tabulated, the first of Sept. 7 referring to the Duplex Compound Pump, the second of Sept. 8 to the High Duty Pump.

With the use of the auxiliary steam line it was possible to run the elevator pump on a separate boiler of 350 HP., the remainder of the plant as well as all boiler feeding was each day on a boiler of 265 HP.

It should be noted that, roughly speaking, boilers and pumps were only on half load so that with a heavier traffic, economy should be further improved.

The five high-rise elevators discharge into auxiliary tanks from which water is supplied to the cylinder through an automatic valve when the pressure water is shut off on the up trip. This system saves 5% of the plunger displacement in high pressure water.

It will be seen that the flywheel pump saved 31% in steam over the compound pump, or in other words that the compound pump consumed 44.1% in excess of the flywheel pump.

Costs are figured for services referred to as including necessary losses such as leakage, slip and water consumed by pilots and motor valves.

Thanks are due to Mr. F. E. Glass and Mr. Noble C. Butler, Jr., who have assisted me in conducting above tests, also to Chief Engineer Thure Larssen of the Plunger Elevator Co. for drawings and data supplied for publication before the society.

Heights of floors of Trinity Building.	ft.	ins.	Elevator travels.	ft.
Sub-basement	12	6	Basement to 3d	49½
Basement	13	6	Basement to 21st	282
1st	19	6	Sub-basement to 21st	284½
2d	16	6	3d to 8th	68½
3d to 5th, inclusive	14	6	3d to 11th	106
6th to 16th, inclusive	12	6	2d to 11th	122½
17th	13	6	2d to 18th	211
18th	13	0	8th to 11th	37½
19th and 20th	12	6	11th to 18th	88½
21st	11	0	18th to 21st	38

Data of Plunger Elevators in Trinity Building.

Diameter of all plungers, 6½ ins.
Thickness, freight and long run, ⅝-in.; short run 9/16-in.
Total plunger weights with central rope: freight, 8,425 lbs.; long run passenger, 8,460 lbs.; short run passenger, 4,000 lbs.
Counterweights, freight elevator, 8,000 lbs.; long run elevator, 7,900 lbs.; short run elevator, 4,700 lbs.
Ropes, counterweight ropes per ft., 7.2 lbs.; total weight, freight, 2,150 lbs.; long run passenger, 2,050 lbs.; short run passenger, 1,121 lbs.
Weights of car: Frame and panels, freight elevator, 3,500 lbs.; long run passenger, 2,500 lbs.; short run passenger, 2,300 lbs.
Weight of each passenger cab, 1,125 lbs.
Friction each machine, up, 500 lbs.; down, 300 lbs.

Tests of Trinity Building Plunger Elevators for Speed and Control.

No. 3 Express, load 1,617½ lbs. Base to 21st floor, 282 ft.
Up in 43 secs., 393 ft. per min. ave. speed; highest speed per min., 438 ft.
Down in 27 secs., 629 ft. per min.

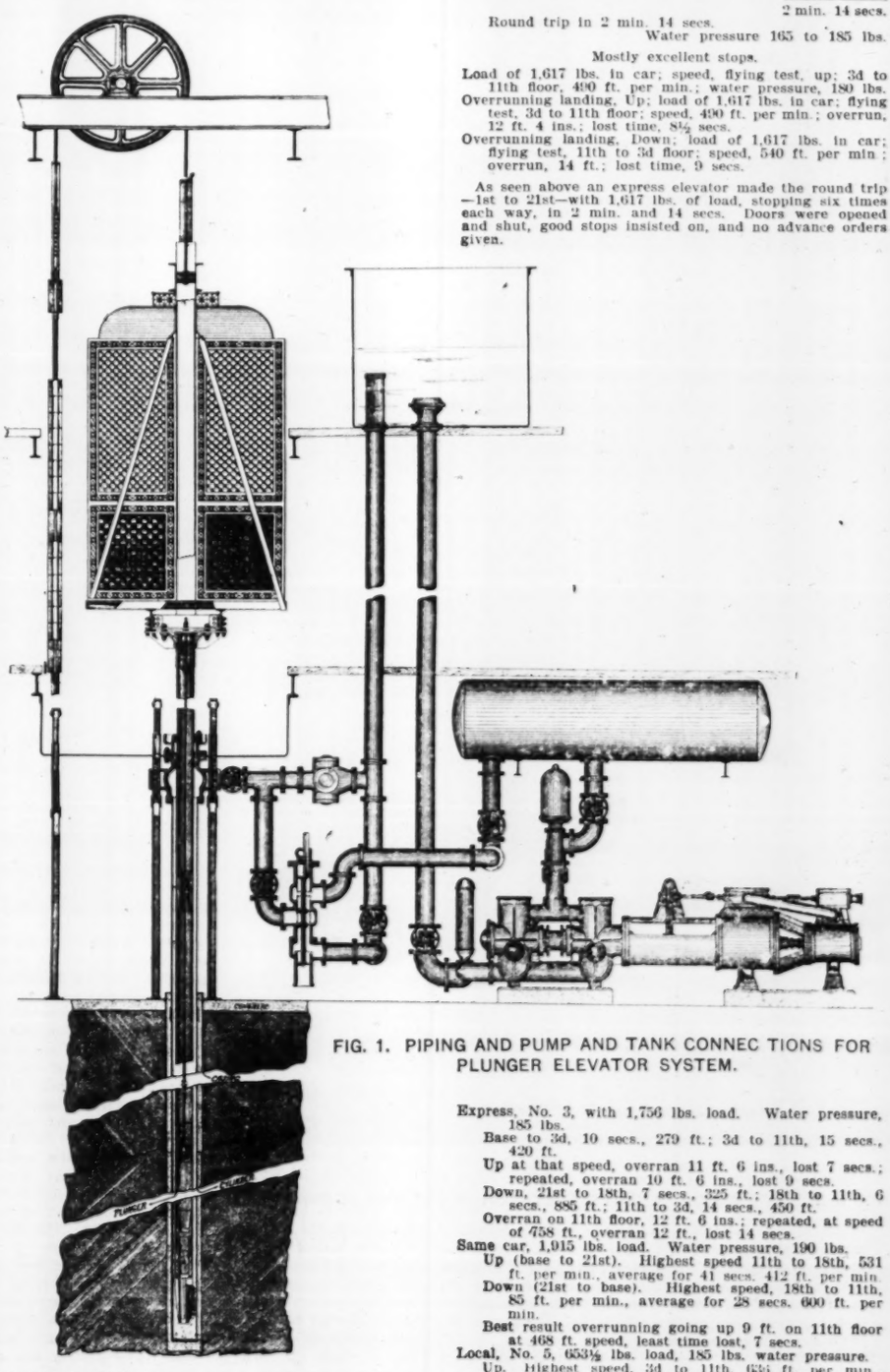


FIG. 1. PIPING AND PUMP AND TANK CONNEC TIONS FOR PLUNGER ELEVATOR SYSTEM.

Overrunning best:
Up, 12 ft. 4 ins.; lost 8 secs.; speed was 490 ft. at 11th floor.
Down, 14 ft.; lost 9 secs.; speed was 540 ft. at 11th floor.

Base to 21st:
6 stops Up, 1 min. 25 secs.; repeated, 1 min. 17 secs.
Down, 1 min. 8 sec..; repeated, 1 min. 25 secs.
2 mins. 33 secs. 2 min. 42 secs.

1st to 21st:
6 stops, 11, 13, 15, 17, 19, 21st. Up, 1 min. 9 secs.
6 stops, 20, 18, 17, 15, 12, 11th. Down, 1 min. 1 sec.
Round trip in 2 min. 10 secs. Water pressure, 170 lbs.

Conditions:
Stops must be no more than 3 ins. out of level. Open and shut door at each stop. Stops ordered after door was shut.
Up, 1st to 21st, 6 stops, 12, 13, 16, 18, 20, 21st .....1 min. 10 secs.
Down 21st to 1st, 6 stops, 19, 17, 15, 13, 12, 11, 1st .....1 min. 6 secs.
2 min. 16 secs.
Round trip in 2 min. 16 secs. Water pressure 185 lbs.
Up, 1st to 21st, 6 stops, 11, 13, 15, 17, 19, 21st .....1 min. 10 secs.
Down, 21st to 1st, 6 stops, 20, 18, 16, 14, 13, 11, 1st.....1 min. 4 secs.
2 min. 14 secs.
Round trip in 2 min. 14 secs.
Water pressure 165 to 185 lbs.

Mostly excellent stops.

Load of 1,617 lbs. in car; speed, flying test, up; 3d to 11th floor, 490 ft. per min.; water pressure, 180 lbs.
Overrunning landing, Up; load of 1,617 lbs. in car; flying test, 3d to 11th floor; speed, 490 ft. per min.; overrun, 12 ft. 4 ins.; lost time, 8½ secs.
Overrunning landing, Down; load of 1,617 lbs. in car; flying test, 11th to 3d floor; speed, 540 ft. per min; overrun, 14 ft.; lost time, 9 secs.

As seen above an express elevator made the round trip —1st to 21st—with 1,617 lbs. of load, stopping six times each way, in 2 min. and 14 secs. Doors were opened and shut, good stops insisted on, and no advance orders given.

Express, No. 3, with 1,756 lbs. load. Water pressure, 185 lbs.
Base to 3d, 10 secs., 279 ft.; 3d to 11th, 15 secs., 420 ft.
Up at that speed, overran 11 ft. 6 ins., lost 7 secs.; repeated, overran 10 ft. 6 ins., lost 9 secs.
Down, 21st to 18th, 7 secs., 325 ft.; 18th to 11th, 6 secs., 885 ft.; 11th to 3d, 14 secs., 450 ft.
Overran on 11th floor, 12 ft. 6 ins.; repeated, at speed of 458 ft., overran 12 ft., lost 14 secs.
Same car, 1,915 lbs. load. Water pressure, 190 lbs.
Up (base to 21st). Highest speed 11th to 18th, 531 ft. per min., average for 41 secs. 412 ft. per min.
Down (21st to base). Highest speed, 18th to 11th, 85 ft. per min., average for 28 secs. 600 ft. per min.
Best result overrunning going up 9 ft. on 11th floor at 468 ft. speed, least time lost, 7 secs.
Local, No. 5, 653½ lbs. load, 185 lbs. water pressure.
Up. Highest speed, 3d to 11th, 635 ft. per min., average for 35 secs. 480 ft.; repeated, same result.
Down (21st to base). Highest speed, 18th to 11th, 590 ft. per min., average for 35 secs., 480 ft.
Local, No. 8, 4 men, 653½ lbs. load, 185 lbs. water pressure.
Up (base to 11th). Highest speed, 3d to 8th, 456 ft. Best average for 24 secs., 388 ft.
Down ((11th to base). Highest speed, 8th to 3d, 411 ft. per min., average for 28 secs., 330 ft.; repeated, same result.
Local, No. 9, same load. Water pressure, 185 lbs.
Up (base to 11th). Highest speed, 3d to 8th, 587 ft. per min., best average, automatic for 17 secs. 548 ft.

*From a paper read at the New York Meeting of the American Society of Mechanical Engineers.
†Consulting Engineer, 945 Broadway, New York City.

Down (11th to base). Highest speed, 8th to 3d, 373 ft., best average for 29 secs., 322 ft.
Local, No. 10, same load. Water pressure, 185 lbs.
Up (base to 11th). Highest speed, 3d to 8th, 456 ft., average for 22 secs., 420 ft.
Down (11th to base). Highest speed, 3d to base, 370 ft., average for 30 secs., 310 ft.

DISCUSSION.

Chas. R. Pratt.—The power plant of an elevator system will always vary with the conditions of the building; the question is, which type of elevator possesses the greatest degree of safety, durability and economy. With the exception of those smaller installations, apartment houses, etc., in which the source of power demands direct electric elevators we are constantly asked to decide between plunger elevators, various types of hydraulic cable elevators, and various types of direct electric elevators, each claiming great superiority over all others. This diversity of opinion is the natural result of the rapid increase in rise and speed, each manufacturer trying to meet these requirements in his own way, to the confusion of the purchaser.

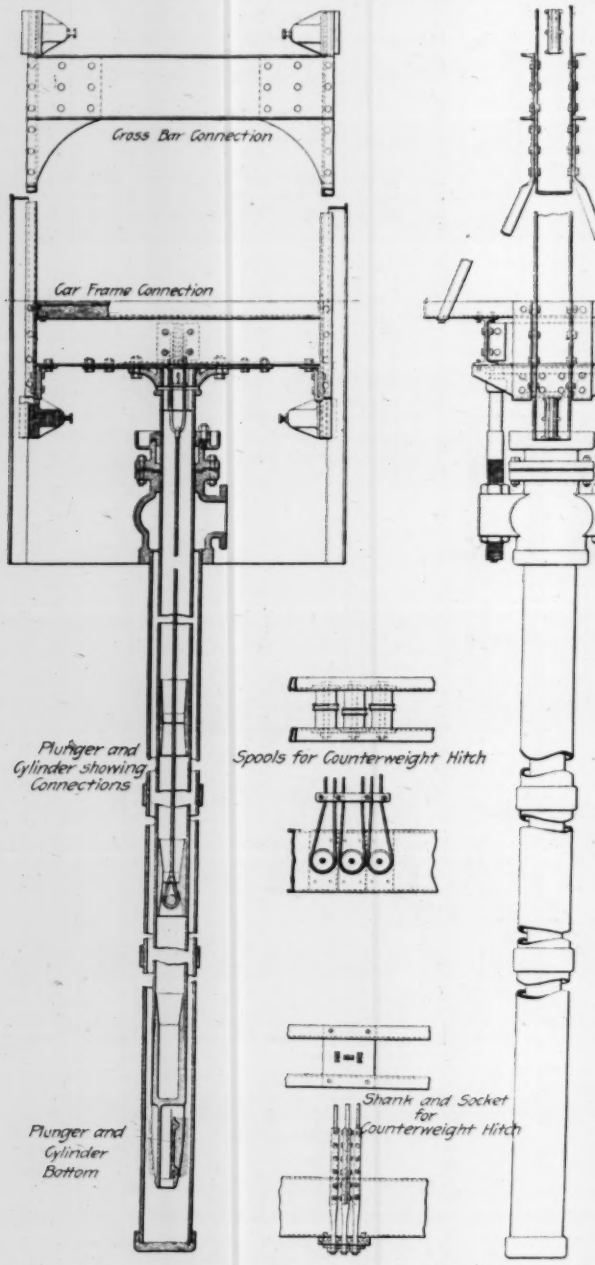

Cross Bar Connection
Car Frame Connection
Plunger and Cylinder showing Connections
Spools for Counterweight Hitch
Shank and Socket for Counterweight Hitch
Plunger and Cylinder Bottom

FIG. 2. DETAILS OF PLUNGER ELEVATOR PARTS AND CONNECTIONS.

Has the plunger elevator established its claims of superiority? When it rose from its forty years' limitation of about 50 ft. rise, the following difficulties were anticipated: 1. Cost and accuracy of boring. 2. Stiffness and strength of the plunger tube. 3. Space saved. 4. Durability and economy in repairs and maintenance. 5. Acceleration of so great a mass at car speed. 6. Efficiency. 7. Safety.

As to the means:

1. Cost and Accuracy of Boring.—A shot drill, constructed of a 12-in. diameter pipe, which bores a hole 13 ins. in diameter, driven at 100 R. P. M. by a 20 HP. electric motor, drills holes through solid rock for a cylinder tube 10 ins. outside diameter. Solid columns of rock up to 15 ft. in length, straight and true, are removed from the hole. This leaves a clear space of 1½ ins. between the outside of the cylinder and the bore of the hole, which is filled in with sand; and which permits the cylinder to be withdrawn from the hole. This has been done to bore the hole deeper to obtain higher rise of car travel, but 50 years' record fails to show an instance of having to remove a cylinder to repair leaks.

Just what amount of deviation from a plumb line occurs in boring these holes would be difficult to determine, but all observations of the plunger tubes indicate such accuracy that the plunger will never be injured. A soft metal brush guides the bottom of the plunger tube against the walls of the cylinder and prevents injury to the cylinder. These brush guides are easily renewed; they are shown in Figs. 1 and 2 of Mr. Herschmann's paper.

2. Stiffness and Strength of the Plunger Tube.—In a high-rise plunger elevator, between the car and the top of the cylinder, there is a neutral point, where the plunger tube is under neither compression or tension. This is due to the weight of the counterweight ropes, which compensate the varying hydrostatic head of the pressure at the bottom of the plunger tube. Therefore, the only part of the plunger tube which is under a compression strain equal to its area times 185 lbs. per sq. in. water pressure, is directly at the top of the cylinder, and from there up to the neutral point this compression strain steadily falls to zero. This accounts for a limited free oscillation of the plunger tube, as it hangs in part like a pendulum from the car. This motion has no element of danger or injury to the plunger.

More graphically explained: We find the neutral points in the "long run passenger elevator" in the Trinity Building to be at the following heights from the top of the cylinder:

206 ft. with 3,983 lbs. car load = 95 lbs. per sq. ft.
154 ft. with 2,520 lbs. car load = 60 lbs. per sq. ft.
64 ft. with no load in the car.

Reinforcing the tensile strength of the plunger tube by two plow steel ropes inside the plunger, as shown in Figs. 1 and 2, is really an unnecessary precaution, taken possibly to satisfy the skeptical layman. The long rock, the only wear being that caused by the light pressure of a soft wire brush.

The conditions affecting the wear of plunger tubes up to 300 ft. rise, appear to be no different from those affecting the wear of those plunger tubes of shorter rise that are still in perfect condition after 50 years' constant service. The plunger packing is double-cupped leather rings, keeping a perfectly tight joint for over six months and easily removed. The valve, Fig. 3, is essentially the same as any other hydraulic elevator valve, the only repairs being a few small cupped leather packings.

The counterweight ropes, being used principally for their own weight, are under very light tension, and bending only once over large diameter sheaves, are likely to last 40 years or more. The overhead sheaves are good for the same period. In engineers' attendance there is less required than for any other type of elevator and the possibility of interruption to service is very remote.

We are, therefore, led to infer that the plunger elevator has practically no charges against it for depreciation or repairs in excess of about 2% of its first cost, in which the repairs proper are about ⅛ of 1%.

5. Acceleration of so great a mass at Car Speed.—We have only to refer to Mr. Herschmann's figures to satisfy ourselves that the acceleration of this mass is no obstacle to quick stops at high speed. In the test which he reports a round trip from the basement to the 21st floor was made with 1,617 lbs. load in the car in 70 seconds, and then making 6 stops up and 6 stops down, "doors were opened and shut, good stops insisted upon, and no advance orders given, most excellent stops" were made, and the round trip took 134 seconds, as there were 64 seconds lost in making 12 stops, an average of 5.33 seconds was required to come to stop, open and shut the door, and resume full speed. It is doubtful if any other type of elevator could accomplish this.

6. Efficiency.—The efficiency of an elevator cannot be determined by the coal consumption per car mile. Mr.

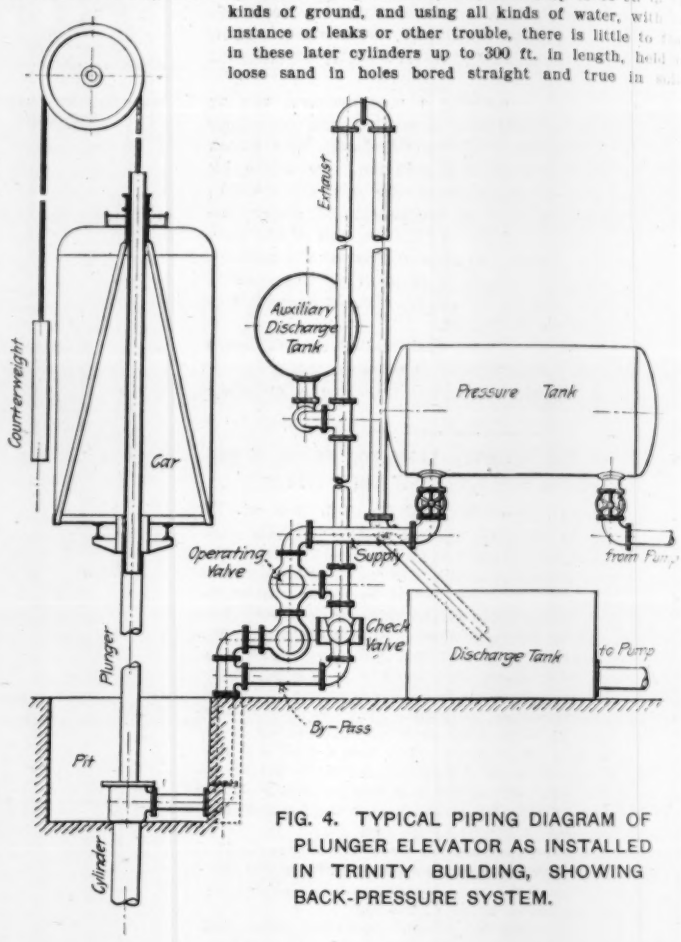


FIG. 4. TYPICAL PIPING DIAGRAM OF PLUNGER ELEVATOR AS INSTALLED IN TRINITY BUILDING, SHOWING BACK-PRESSURE SYSTEM.

couplings and strong anchorage to the car have a factor of safety of probably 20 to 1, which factor is maintained from there to the counterweight.

3. Space Saved.—In the specific instance of the Trinity Building the only alternative system considered was the vertical cable hydraulic elevator, the space saved by the plunger elevator amounted to about 150 sq. ft. per floor, or 3,150 sq. ft. for the 21 renting floors.

4. Durability and Economy in Repairs and Maintenance.—The parts subject to wear or deterioration are the following cylinder, plunger and packing, valve and packing, counterweight ropes, overhead sheaves.

With a record of many thousand plunger elevator cylinders for the last 50 years, buried up to 50 ft. in all kinds of ground, and using all kinds of water, with no instance of leaks or other trouble, there is little to fear in these later cylinders up to 300 ft. in length, held in loose sand in holes bored straight and true in solid

Herschmann's paper gives us the efficiency of the Trinity Building power plant and elevators, in which 53 lbs. of coal per car mile with the compound pump, and 34.4 lbs. of coal per car mile with the Laidlaw-Dunn-Gordon flywheel pump, shows as high efficiency as any hydraulic elevator system.

Mr. Herschmann alludes to a method of saving high pressure water, applied only to the five high-rise elevators, which are express to the 11th floor and local from the 11th to the 21st floor, the other five elevators being local from the 1st to the 11th floor, remarking that "This system saves 5% of the plunger displacement in high pressure water." As this system only saves high pressure water when stopping on the uptrip, and cuts off about 6 ft. below the landing, it saves 50% of the high pressure when stopping at every floor, thus doubling the efficiency for that kind of service. But in the Trinity Building it is used only on the five express elevators, which average about 6 up stops each, out of a possible 210 up stops for the 10 elevators. Using only 30 out of a possible 210 up stops, cuts down this saving to one-seventh of what it would be with all ten elevators stopping at every floor.

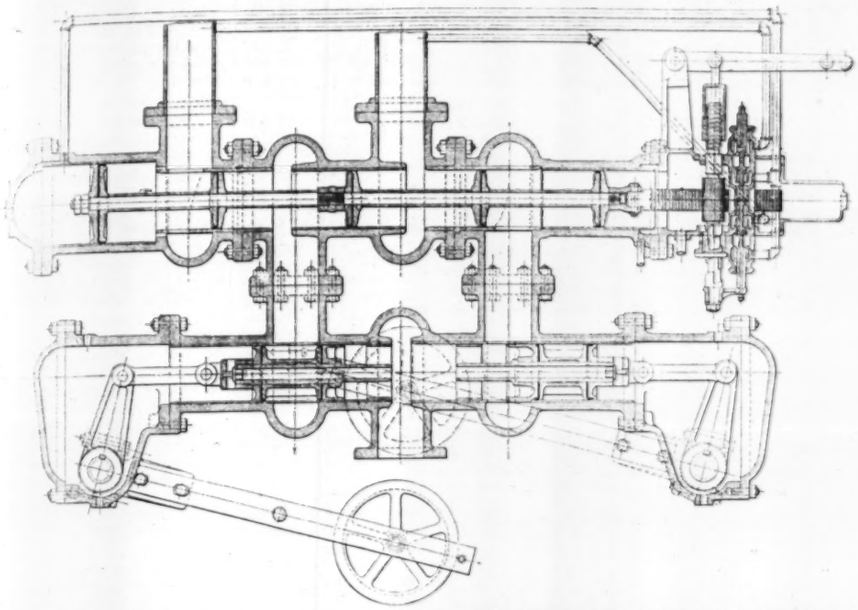


FIG. 3. PILOT CONTROLLING VALVE FOR PLUNGER ELEVATOR AND AUTOMATIC STOPPING VALVE FOR END OF RUN.

Fig. 4 shows this system as installed in the Trinity Building. On the down trip the water is discharged through the "operating valve" to the "auxiliary discharge tank," and through a stand pipe head 52 ft. above the cylinder port, down into an open "discharge tank."

On the up trip the operating valve cuts off the "supply" from the "pressure tank" about 6 ft. below the landing, the "check valve" opens, and the momentum of plunger, car and counterweight, assisted by the 52 ft. head of water through the "check valve" into the cylinder carries the car to the landing.

But the discharge of 52 ft. head of water into an open discharge tank is sheer waste of power. Fig. 1 shows the proper connections for turning this back pressure of the plunger back into the pump's suction, with the further advantage of reducing the counterweight by the amount of pressure derived from that head of water.

7. Safety.—The plunger elevator up to the present time is the only one exempted from using a safety device on the car. Is it entitled to this exemption? (a) By durability of ropes and all other parts? Yes. (b) By factor of safety in structure? Yes. (c) By normal hydraulic retardation? (d) By normal limit stops? (e) By automatic limit stops?

(c) The normal hydraulic retardation of a plunger elevator should be greater than in any other type of hydraulic elevator on account of the impact of water between the bottom of the plunger and the walls of the cylinder as the velocity increases, and it should be more reliable on account of the cylinder always being full of water.

(d) Normal Limit Stops.—The lower limit stop is on two or more long spring buffers. The normal upper limit stop is by an open discharge at the top of the cylinder when the wire brush guide rises above the packing, the counterweight at the same moment landing on spring buffers.

Automatic Limit Stops.—The deflected limit rope operating the "automatic stop valve," shown in Fig. 3, is probably the most reliable of any form of automatic limit stop.

As the measure of success is actual results accomplished, rather than predictions based upon theory or design, the replacement of modern hydraulic and electric elevators by plunger elevators is significant; notably at the Park Building in Pittsburgh, and at the Land & Title Building in Philadelphia, each formerly equipped with 6 vertical hydraulic cable elevators, and each having recently experienced serious accidents; on account of which, the owners at great expense have replaced these vertical hydraulic cable elevators with plunger elevators solely on the question of safety. The owners of many other prominent buildings have replaced modern hydraulic and electric elevators with plunger elevators on account of safety, reliability of service and economy, and the rapid increase of plunger elevator installations in our finest, largest and highest buildings demands our most serious consideration. Their recent achievements apparently justify their claims. If there are faults we should discover and prove them to be faults. If they have achieved success, we should recognize it.

In closing this discussion, I wish to call attention to the demand for an efficient electric pump that will compete in price with steam pumps. The frequent demand for electric pumps for hydraulic eyevators, which are rejected nine times out of ten solely on account of their greater first cost, should be sufficient incentive to produce an electric pump that will meet this demand.

W. H. Bryan.—The figures given in the paper bear out surprisingly the writer's statements in the discussion of Mr. Thos. E. Brown's paper on "Passenger Elevators" read before the International Engineering Congress of 1904, namely, that in economy of operation the electric elevator far exceeds any type of hydraulic elevator. In comparing with the plunger hydraulic elevator, the saving in cables in the latter reduces the advantage of the electric machine, and there are also other countervailing features; in the matter of power economy, however, the statement holds.

E. S. Matthews.—The saving of space by plunger elevators over other types of hydraulic elevator in the Trinity Bldg. has been computed by the architect of the building, Mr. F. H. Kimball, to be equivalent to an annual income of about $10,000.

Thos. E. Brown.—The makers of the Worthington duplex compound pump have never been willing to guarantee a lower steam consumption than 70 lbs. per water HP.-hr. The tests reported by the author show a very much greater economy (42 lbs. steam per water HP.-hr.). The combination of automatic check valve with automatic limit stop in the Trinity Bldg. elevators contains an element of danger; the check valve should be outside of the limit stop valve. The main operating valve should preferably be graduated so as to be independent of a check valve, but this is a delicate adjustment. The Trinity Bldg. elevators are closely paralleled among hydraulic cable elevators by the high-rise elevators of the Hanover Bank Bldg., New York City; these have 19-in. cylinders, geared 8 to 1, the cars are underbalanced by 810 lbs., and an average speed of 608 ft. per min. is made. The Trinity Bldg. elevators, having no safeties except top and bottom limit stops, may be subject to considerable excess speeds; under given circumstances, for instance if the check valve and the bottom limit stop fail, the car may acquire a speed of 1,600 ft. per minute in descending, a dangerous speed at which to strike the bottom of the shaft.

R. P. Bolton.—The paper is very disappointing as a discussion of the plunger elevator or a description of the Trinity Bldg. installation. On its face it deals with elevators, but in effect it is a comparison of duplex compound and high-duty pumps. The boiler tests reported are by no means in accordance with the standard boiler-test code of the society; they represent only one day's observation and are undoubtedly vitiated by the effect of starting with a well-filled fire in the morning as is usually done in such plants. The figures for elevator traffic, 5,000 persons in one case and 4,500 in another, are round numbers which appear to be mere guesses; and the distance traveled by the passengers is not known. Ac-

ECONOMY TEST OF TRINITY BUILDING ELEVATOR PLANT.

	September 7, 1905	September 8, 1905
Horse-power boilers developed	148.9 average	104.05 average
Coal burned in the 9 hours	7,000 lbs.	4,400 lbs.
Quality and cost of coal	Buckwheat, No. 1; $3.40 long ton.	
Calorific test of coal	75.04 fixed carbon; 11,650 B. T. U.	
Moisture in coal	2¼%	2¼%
Ashes in lbs.	1300	750
Ashes, per cent. of dry coal	19	17
Evaporation, per lb. of coal	6.29	6.93
" " " " dry coal	6.45	7.10
" " " " combustible from and at 212° F.	8.36	9.07
Boiler and furnace efficiency	56%	61%
Coal, lbs. per car mile	53	34.4
Coal, lbs. per KW.-hr., including house service and all boiler feed	11	13
Coal, cost per car mile	8.04 cents	5.22 cents
Coal, cost per KW.-hr., including house service	1.68 "	1.96 "
Coal, cost per lamp	0.084	0.088
Round trips made by locals, 848—1st to 11th—142 ft. / 8—Basement to 11th—155 ft.	121,660 ft.	.....
Round trips made by locals, 861—1st to 11th—142 ft. / 16—Basement to 11th—155.5 ft.	.....	124,750 ft.
Round trips made by express, 795—1st to 21st—268.5 ft. / 47—Basement to 21st—282 ft.	226,174½ ft.	.....
Round trips made by express, 680—1st to 21st—268.5 ft. / 105—Basement to 21st—282 ft.	.....	212,190 ft.
Average number feet per hour	38,648	37,487
" " of car miles per hour, 131.74÷9	14.63	14.18
Number feet totals for day of 9 hours	347,834	336,940
Elevator fuel per hour, 777 lbs. costing	$1.18	.....
489 " "	.....	$0.71
Electric and house pump fuel per hour	$1.03	.....
" " " " " " " 640 lbs. costing	.....	$0.97
Cost of coal per gross ton	$3.40	$3.40
Steam used per indicated horse-power hour, pounds	38.67	25.92
Steam used per water horse-power hour, pounds	42	29.14
Mechanical efficiency of pump, per cent	0.927	89.6
Indicated pump horse-power (mean of cards)	126.19	130.29
Water horse-power delivered by pumps	117	116.7
Steam used per mile car travel, lbs.	350.5	252.8
Fuel used per mile car travel, lbs.	53	34.4
Car miles for day of 9 hours	131.74	127.63
Pump used...Henry R. Worthington Duplex Compound, 21 x 34 x 18 x 24	yes	no
" " ...Laidlaw-Dunn-Gordon Flywheel, 17½ x 22 x 22 x 12½ x 30	no	yes
Revolutions in 9 hours	9,473	13,896
Revolutions per minute	12	25.7
Slip total, per cent	4.3	3.87
Excess of steam over that taken by flywheel pump	44.1%	.....
Coal in excess of coal for flywheel, per cent. (same evaporation)	38%	.....
Water delivered per revolution, gallons, actual	95.03	44.09
Number of passengers in 9 hours	4,500	5,000
Cost of coal per passenger lifted	0.24 cent	0.13 cent
Water horse-power per car mile	7.99	8.23
Actual water pumped, gallons	615,130	612,758
Average water pressure during day	176 lbs.	177 lbs.

curate expression of coal consumption is therefore impossible. The paper errs, further, in not stating the full facts connected with the Trinity Bldg. elevators. The intended speed of lifting was 600 ft. per min. with a load of 1,500 lbs., but on test they reached a speed of only 500 ft.; the intended speed will never be reached in this plant. Even for the actual performance the water pressure was raised from 165 lbs., the designed pressure, to 185 lbs. per sq. in., at which pressure they are now being operated. The distance required to stop the cars appears to be twice as great as is considered allowable in other types of hydraulic elevator; the overrun figures given in the paper show the same effect. The plant indeed seems to jeopardize the safety of the public that must ride in the elevators. The claim is often made that no accident has happened with plunger elevators; but in this very plant an accident already has occurred, an employee being killed. The precise circumstances are not known, as the car came down on the automatic limit stop with the operator dead in the cab, crushed possibly at one of the floors. In another case the automatic limit stop broke, but fortunately this was on the up run. Even in the latter case there is no guarantee of safety. There is only 2-ft. clearance between top of cab and overhead steel work, which is dangerously low at the speeds which the elevators may reach. To run cars at possible speeds of 885 ft. per min. without any safeties other than limit stops must be adjudged dangerous. The ruling of the New York City Bureau of Buildings, that no safeties are required on plunger elevators, originated when the speaker installed plunger elevators in the Ansonia Hotel, at a time when no reliable safeties for the purpose appeared available; but those elevators run at very moderate speed, and the speaker consented to put them in without safeties only on the basis of extremely careful design of the valves and gearing. In the Trinity Bldg. installation, the approval of the authorities bases on a test where it is claimed a 6-in. valve in the supply pipe was opened with the result that the elevator came down slower than it had gone up. As such a result is contrary to physical fact (the elevators are underbalanced), the inference is that the valve was not open as stated.

Thos. E. Brown.—(In answer to a query as to how much the plunger sways laterally.) The swaying which it is claimed has been observed as 1 in. is in fact not only as much as this but reaches 6 or 8 ins., and on heavy down stops the plunger sometimes even touches the side of the hatchway. What danger lies in such motion will long be a matter of opinion; the speaker's calculations indicate that it does not produce excessive stress, but Professor Lanza in a report on the subject has asserted that it is dangerous and in time will destroy the plunger.

George Hill.—Coal consumption of elevator plants as shown by tests is not the criterion of elevator economy; the yearly coal consumption is the thing. An installation of four plunger elevators of long travel in a New York hotel shows very low yearly coal consumption compared with similar installations of other elevators. The electric elevator, in the speaker's opinion, is as good as the hydraulic for speeds below 400 ft. per min., but for higher speeds it is not economical.

A. J. Herschmann.—The figures 5,000 and 4,500, for daily passengers, were obtained by actual count and must therefore be taken as correct. Mr. Bolton's statement that the water pressure was raised above that originally designed is, as far as the speaker knows, without foundation. The fatal accident mentioned by Mr. Bolton was carefully investigated, and nothing was found that pointed to any relation between the accident and the system of elevator operation.

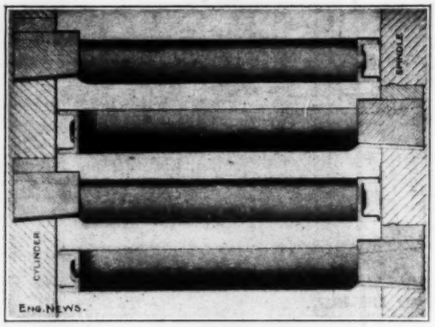
THE ALLIS-CHALMERS STEAM TURBINE.

We noted in our issue of Nov. 9, p. 496, brief particulars as to the design of the steam turbine of 9,000 HP. furnished by the Allis-Chalmers Co., to the Brooklyn Rapid Transit Co. Additional data are now furnished by the Allis-Chalmers Co. regarding the details of the blading in their turbines, and we present it as follows:

The roots of the blades are formed in dovetail shape by special machinery, and are inserted in slots cut in foundation or base rings; these slots being formed by special machine tools in such a way as to exactly conform to the shapes of the blade roots. The foundation rings themselves are of dovetail shape in cross section and are inserted in dovetailed grooves cut in the turbine cylinder and spindle respectively, in which they are firmly held by key pieces, much in the same way that the well known "Lewis bolt" is fastened. In order to further ensure the integrity of the construction, the key pieces or rings after being driven into place are upset into undercut grooves.

Another noticeable feature of the blading is the method of reinforcing and protecting the tips of the blades. This point in steam turbine design is one upon which much thought has been expended by various inventors, and the Allis-Chalmers Co. claim that the construction employed by them successfully solve all difficulties. In forming the blades a shouldered projection is left at the tip. This is inserted in a slot punched in a shroud ring, the slots being punched by special machinery in such a way as to produce accurate spacing and at the same time form the slots so that they will give the proper angles to the blades independent of the slots in the base ring. After the blade tips are inserted in the slots in the shroud rings they are riveted over by specially arranged pneumatic machinery.

The shroud rings are made in channel shape, with outwardly projecting flanges which, after assembly in the turbine, are turned and bored to give the necessary working clearance. The flanges of the channels are made so thin that, although amply sufficient for stiffness, the shroud ring does not have the disadvantage of a solid shroud which acquires a dangerous temperature by friction in case of an accidental contact of the rotating and stationary parts. It is claimed for this construction that the blades are stiffened against the effect of vibration in a much more substantial manner than by any other means thus far employed, while the use of a protecting shroud ring enables the working clearance to be made smaller than in the case of naked blade tips, without danger in case of accidental contact, thus reducing the leakage loss to a minimum; the



Section of Blades of Allis-Chalmers Steam Turbine Showing Method of Fastening.

leakage past the blade tips being the principal source of loss in the steam turbine. As to the safety from damage in case of accidental contact, it is claimed that this has been proved by experiment with actual blading by throwing the bearings out of center so as to produce contact without detrimental results. An incidental advantage claimed for this construction is that if by chance a blade should prove defective it is so held in place by the shroud ring that it cannot possibly work loose and produce damage.

By the method of construction described the entire blading is produced by machinery, thus eliminating the personal equation which enters into blading done by hand work, which depends upon the skill of the individual workmen. Besides ensuring that every blade is securely fastened, all blades are necessarily set at exactly the designed angle and pitch; the openings between blades, upon which in great part the economical performance depends, being absolutely uniform. The blading is made up in half rings in the blading shop and is carefully inspected before being inserted in the turbine.

Reference to p. 571 of our issue of Nov. 30 will show that the above-described construction is very similar to, if not identical with, the construction used in the Parsons marine steam turbines.

THE ORGANIZATION OF THE OPERATIVE FORCE IN INDUSTRIAL ESTABLISHMENTS.*

By H. F. J. Porter, M. Am. Soc. M. E.†

We have insensibly drifted away from the patriarchal system of management which existed as late as twenty-five or thirty years ago, in which the owner of a shop was manager, superintendent and workman, who knew little about shop organization but associated with his men on intimate and cordial terms.

As manufacturing plants have grown in size and the workmen have differentiated their trades, a type of military organization has gradually developed in the shops in which the manager, superintendent and foremen are officers who instead of being expected to take part in turning out the product of the plant are, on the contrary, experts in shop management, and see that the machine of which the workmen are parts is kept in [illegible] working order.

In this way the old personal touch b[illegible] and men (which terms still adhere in [illegible] has disappeared entirely. But human n[illegible] changed. That element still exists in th[illegible] and if the full strength of the latter is to [illegible] must be accorded recognition. No matte[illegible] may be an accounting system, if it is car[illegible] intelligently applied, it becomes worse t[illegible] because it will be misleading in its result[illegible] how perfectly suited to their purpose the [illegible] efficient in quality or shape the cutting [illegible] they are skilfully manipulated the product [illegible] satisfactory, and so in either case the ou[illegible] enterprise possessing mediocre talent in [illegible] forces will be jeopardized. In order then [illegible] successful issue to a manufacturing ventu[illegible] look beyond the mechanical assets to the [illegible] for efficient service possessed by the org[illegible] supervisors, clerks and operatives; and it w[illegible] that the measure of success attained will be [illegible] by the standard of excellence of those quali[illegible]

I do not wish, however, to be understood [illegible] rating the value of a high grade mechanical [illegible] for if success is to be attained the equipment [illegible] the best of its kind for the purpose. But I [illegible] emphasize the greater necessity of possessing [illegible] efficient an organization as can be secured; for [illegible] organization can make the best of a poor [illegible] and produce good results whereas an incapable organization will not only fail to make a fine equipment productive of good work but probably in a short time will destroy the equipment itself.

The lesson taught generally by the foremost enterprises of the day, in their respective industries, is that their success has been largely due to the efficiency of their working forces. Thus in recent years the importance of possessing a high grade organization has impressed itself more and more upon the mind of the business manager so that at the present time this possession is considered, by those who are most competent to judge, by far the most valuable of all commercial assets.

Considering for a moment the functions of the organization, together with its circumscribing limitations, it must be recognized initially that if one man autocratically dominates it, its scope of expansion can never be any greater than what he can himself devise. Also that the character of work which may be realized from the organization as a whole will be no better than can be produced by the individuals that compose it.

If honest workmanship is desired, honest workers will be necessary for its accomplishment; if quantity of output is expected, skill and enthusiastic devotion to duty must be possessed by the operatives; if improvement in processes and perfection of product are to be hoped for, the workers must have intelligence and be given suitable opportunities for its expression; if the organization as a whole is expected to grow, not only in size but in strength and character, facilities must be offered for the improvement of the individuals and inducements made for taking advantage of them; if untiring aggressiveness against competition is desired, absolute confidence in the enterprise and its product will have to be developed in the organization, and if harmonious cooperation between departments and management is to be effected, a spirit of mutual helpfulness must be imbued in the individuals comprising them respectively.

Although we have seen that the human asset is of greater importance in an industrial enterprise than its mechanical possessions, I think I can safely say that infinitely more pains are taken in obtaining a machine or tool, to see that it is covered by detailed specifications and inspected during construction and before acceptance than is given to securing the man who will be put in charge of it and held accountable for results from it afterwards. We rarely hear of a recognized labor or employment department in a shop, and when there is one it is seldom intelligently administered. Usually little care is taken in the selection of the men, and no thought is given to their improvement during their time of service. They are taken on and laid off without a thought of consideration for their welfare or convenience, and they frequently live with a sword of Damocles hanging over them, continuously expecting on any pay-day to find their discharge ticket in their envelope. No men can work at their best efficiency under these conditions.

Now there is one marked difference between machines and the men who operate them which should be noted here. Machines, no matter how well they may be cared for, depreciate from five to ten per cent. per year owing to the advent of other and improved machines, while men, if they are properly cared for may appreciate in value several hundred per cent. in the same time. Yet I maintain that as a general rule machines and tools are nurtured, fostered and preserved long after their period of usefulness has expired, while the permanency of service of the men of the organization who operate them receives comparatively no consideration whatever.

*Extracts from a paper presented at the New York meeting of the American Society of Mechanical Engineers.
†Consulting Engineer, 1 Madison Ave., New York City.

it cannot be expected that the men of an organization will show any spontaneous enthusiasm for interest in or loyalty to a management that openly displays so little interest in their welfare.

The National Civic Federation has established local Industrial Betterment branches about the country with the object of encouraging manufacturing concerns to adopt the most approved methods of organization and management in the hope of bringing about a better feeling between employer and employee. An effort in this latter direction must be at the foundation of every individual movement on the part of any manufacturing concern which desires to advance along modern lines. It is only reasonable to suppose that if employer and employee work together for a common end the enterprise will pay better than if each works for his own interest simply with the full persuasion that the other is trying to get out of him all he can. Co-operation must supplant antagonism to secure a full meed of success. So also of two competing concerns that one which gains the closest co-operation of its working organization, other things being equal, will have just that much advantage in its race for supremacy.

In any manufacturing enterprise a standing committee on which both employees and management are represented which meets at stated intervals is an excellent method of "getting together" those who are competent to act that each may see the other side of the shield and obtain the other's point of view. There are frequent occasions arising when the management is anxious to know what attitude the employees would take in case a change in policy is made. On the other hand, the employees from time to time wish to lay a request before the management. In either case some temporary device is usually resorted to to meet the occasion. When a standing committee exists, however, a channel of communication is always open and each side keeps thoroughly in touch with the other on all matters of common interest. An honor system is thereby established among the employees and the discipline improves greatly. I have never failed to see a marked change come over the entire organization as it rose to its responsibility as soon as the members felt that they were accorded recognition as rational beings and to be consulted on matters of common interest. Generally the rank and file of the working organization is considered in the same category as the privates in an army, they are not supposed to think but to do as someone above them has planned. The usual result, as might be expected, is that they do not use their brains for the benefit of the concern.

All questions regarding systems of wage payments should come before the standing committee. The introduction of any of the various merit systems can be brought about in a shop with little difficulty if the subject is intelligently discussed by the committee in advance. In this country an appeal to reason is always accorded sympathetic reception, whereas the forcible application of a policy based on general assumptions meets with merited resistance. And I should say here that as all men work primarily for their support the wage question is the one which must be settled first and satisfactorily before any schemes of industrial betterment can be effectively developed. Men work for wages, and will go where they can get the most pay. But of two concerns, each paying the same wage, the one which extends the better treatment to its employees will be favored by the applicants for employment and by judicious methods it can obtain the better class of help.

Some work of common interest must be developed to engage the attention of the standing committee and the sub-committees which later may be appointed to handle details. The Suggestion System now so generally adopted by the foremost concerns is a good subject for the committee to handle. This system develops in the operatives the power to observe, improves their capacity of initiative and inspires their ambition. It has besides the great advantage of being in itself a paying institution both to the employee and the company, when the latter pays well for valuable suggestions. A recent magazine article over the name of the Welfare Manager of the National Cash Register Company, which has probably gone into industrial betterment projects deeper than any concern in this country, says that this system will net his company the neat sum of $30,000 this year.

This system may include suggestions from the employees regarding improvements in their own conditions of comfort and work. No one knows better than the workman himself if he is not working under the most comfortable circumstances, but he will naturally hesitate to complain. Yet everyone knows that a man when comfortable can do better work than when he is uncomfortable, and should be given an opportunity to express himself regarding his condition.

The system should also include suggestions regarding improvements in processes and methods of work. The operative, if encouraged to think, will soon effect great savings in the work at which he is more of an expert than anyone else who is not constantly engaged at it. I have recently seen a product considerably redesigned, the process of manufacture simplified and made much cheaper and the company put upon its feet largely through the introduction of the Suggestion System.

Meetings of the foremen should be held regularly, and instruction given to them in the proper handling and management of men to secure the best efficiency within the limits of fair and just treatment. It must be understood that in order to secure the best quality of work the mind of the worker must be as free as possible from worry about his position. Peace of mind cannot be maintained while conditions exist which entail arbitrary discharge from service or unexpected reduction of wages, nagging by foremen who are affected by favoritism, ineffective facilities for service, unpleasant and unhealthful surroundings, danger of accidents from unguarded machinery, or loss of life in inflammable buildings inadequately supplied with means of escape. On the contrary, credit should be given to each employee for every effort to do his part in advancing the interests of the company. A little encouragement at the right time will do much to arouse ambition and enthusiasm, without which nothing of moment is accomplished.

Apprenticeship schools in operation during working hours under the charge of a trained teacher are effective means of developing the mentality of the organization and at the same time of getting in close touch with the employee early in his career, and the longer he stays with the concern and the more money is spent on his improvement the more valuable he becomes as an asset and the greater the effort should be made to retain him in the organization. Schools should be established in the factory during evenings for the purpose of helping the employee to advance in the organization. Energy coupled with character and knowledge guided by tact and discretion will open the avenues of achievement. Care should be taken, however, not to coddle the organization. Coddling engenders weaklings. Extending opportunities so that the employees can help themselves develops self-reliance, self-respect, and, at the same time, regard for the management. Such a policy promotes a strong and healthy organization. Employees are quick to feel any interest taken in their welfare and as quick to reciprocate. To increase the efficiency of an organization so that each employee is not only a passenger in the enterprise but effectively pulls his own weight is the function of this new field of Industrial Engineering.

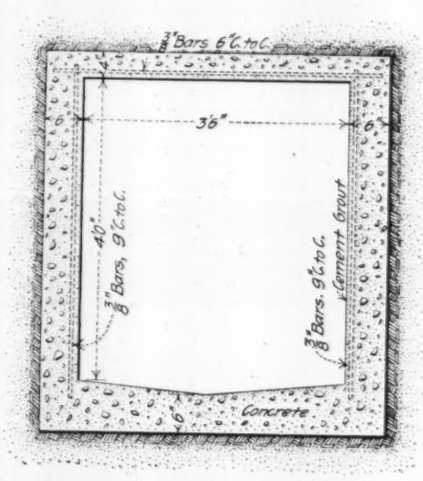


Fig. 1. Standard Section in Excavation, Salt Lake City Water Supply Conduit.

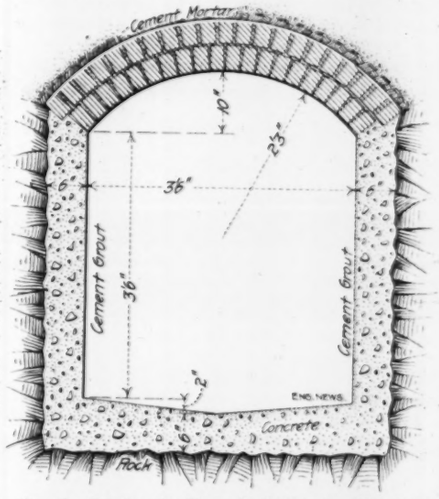


Fig. 2. Section in Tunnel, Salt Lake City Water Supply Conduit.

REINFORCED CONCRETE CONDUIT FOR THE WATER SUPPLY OF SALT LAKE CITY, UTAH.

A reinforced concrete conduit 38,000 ft. long is included in the work now under way for securing an additional water supply for Salt Lake City, Utah. This conduit is known as the Big Cottonwood Conduit, and extends from Big Cottonwood Creek to Parley's Creek, whence a conduit was built in 1891-2 to the city's distribution system.* Later a supplementary conduit to the Parley's Creek conduit will be built to take care of the waters derived from both Parley's and Big Cottonwood creeks, together with a portion of the waters of Mill and Little Cottonwood creeks. The waters of these last three creeks are now being acquired by the city from the farmers who now have the right to use them, the city giving in exchange water which it brings from Utah Lake. The Utah Lake water is not suitable for culinary purposes, but has excellent value for irrigation, to which use the water from the three creeks named is at present put.

Only the new conduit work is considered here. As stated, the conduit is 38,000 ft.; it is partly in excavation, partly in tunnel and partly above ground, a different construction being used for each position. Before considering these separate constructions it may be noted in general that the conduit is built on a hydraulic grade and will, therefore, be subjected to no internal pressure other than that due to the weight of the water flowing in it. The design contemplates an air space of about 5 ins. above the surface of the water when the conduit is carrying its maximum capacity. The line was located to keep the conduit in excavation as much as possible, and when this was not possible to use a viaduct structure.

In the drawings the section, Fig. 1, shows the normal section in excavation. In this construction the roof slab is modified to suit the depth of fill. The design shown is for a cover of less than 5 ft.; for a cover of from 5 ft. to 10 ft. the slab is made

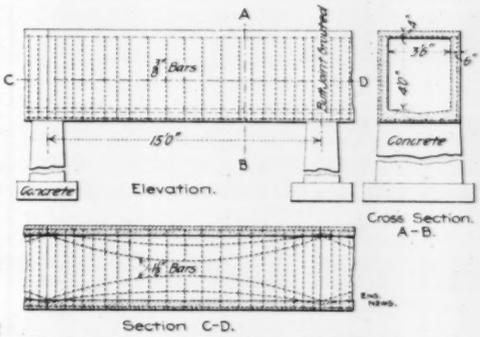


Fig. 3. Aqueduct Construction Above Ground, Salt Lake City Water Supply Conduit.

5 ins. thick and in reinforced with ½-in. bars spaced 9 ins. apart and for a cover exceeding 10 ft. the slab is made 6 ins. thick and is reinforced with ½-in. bars spaced 6 ins. apart. In tunnels of which there will be a few short ones the construction shown by Fig. 2 is used. This section has the same area as that shown by Fig. 1, but owing to evident construction difficulties it was deemed wise to substitute the brick arch for the flat roof slab.

It was deemed unwise to build any conduit on embankment, so that where the conduit runs out of excavation the normal section shown in Fig.

*A full description of the Salt Lake City water supply system as it then existed was published in Engineering News, Oct. 10, 1905.

1 is changed to the section shown by Fig. 3, which is supported on concrete piers spaced 15 ft. apart c. to c. The only change in the conduit proper consists in the addition of suitable reinforcement as shown.

The reinforcement used on all this work is the Ransome twisted steel bar. It will be noted that there is a butt joint over each pier. This section will not be covered, and this seemed the best method of taking care of the expansion and contraction due to changes in temperature. It is planned to grout these joints during cold weather and so throw the conduit into compression under normal conditions. The interior of the conduit and all exposed exterior surfaces will be coated with a grout composed of one part Portland cement and one part fine sand; this grout is to be of the consistency of whitewash and to be applied with a brush.

The concrete used will be composed of 1 part Portland cement, 2½ parts sand, and 4 parts gravel or broken stone. The gravel or broken stone will contain no pieces larger than 1 in. along their greatest diameter, and not more than 5% less than ¼-in. in diameter. Broken stone is subject to the same limitations as regards size that gravel is, except that run of crusher may be used if a deduction from the specified quantity of sand be made equal to the volume of stone dust in excess of the 5% allowed to pass the quarter-inch screen.

The main reasons leading to the adoption of a rectangular cross-section in place of the customary circular or modifications of the circular section were simplicity of construction as regards forms and placing of concrete, with the resulting cheapness in the price per cubic yard, the flexibility of the roof construction which permits the roof to be of only the requisite thickness for the fill over it; the ease with which the reinforcement could be modified so as to allow a concrete girder to be built without any change in cross-section; and lastly, the fact that there was no approach to uniform internal pressure.

The conduit is being built under the direction of Mr. Geo. W. Riter, City Engineer. Salt Lake City, Utah. Mr. Geo. M. Bacon, Assoc. M. Am. Soc. C. E., designed the conduit, and is the engineer in charge of the work. We are indebted to Mr. Riter and Mr. Bacon for the information from which this description of the conduit has been prepared.

PIPE LINE REFRIGERATION.*

By J. E. Starr.†

The scope of this paper is limited to a discussion of distribution of refrigeration by pipe lines laid, by virtue of public franchise, under the streets and public places of cities for supplying refrigeration to all classes of consumers, large and small, or, in other words, a public service distribution.

Only two methods have been employed for distribution: (a) Brine Circulation; (b) Direct Expansion. Boston, New York and Philadelphia each have a considerable street distributing service by brine circulation. The direct ammonia system is installed in Boston, New York, St. Louis, Atlantic City, N. J., Baltimore, Md., Norfolk, Va., and Los Angeles, Cal. It has been installed and discontinued in Denver, Colo., and is now in the course of installation in Kansas City, Mo.

The length of mains installed is not entirely a measure of the importance of the plant from an income standpoint, as the income per mile varies greatly, depending on the shape of the distributing parish. It is regretted that a tabulation showing relation of income to length of main cannot at present be given without violating business confidences. Omitting a very concentrated district of refrigerating demand in Boston, and barren connecting lines in other cities, an average of $12,000 gross income per mile is nearly correct.

The various installations range from one mile of mains to 17 miles.

BRINE LINES.—Brine lines now in operation have the usual two-pipe flow and return system with refrigerator coils connected in multiple. The brine is cooled in brine coolers of the shell and coil type. Brine pumps are of the triplex type driven by direct-connected engines.

The power required for distributing the brine varies directly with the head and inversely as the temperature range of the brine. Assuming a range of 5° between the outgoing and incoming brine and a head of 120 ft. we have $\frac{200 \times 120}{5 \times 33{,}000} = 0.14$ HP. per ton of refrigeration per day delivered to the brine as measured by the brine. Depending on the efficiency of the apparatus this will call for from 0.23 to 0.28 HP. at the motor per ton of refrigeration per day, for pumping the brine through the distribution pipe system. (The power required to produce the refrigeration itself is of course not included in these figures.)

The insulation of the mains is usually effected by laying the pipe in a wooden box and covering with an insulating material soaked in some moisture-resisting compound. Hair felt soaked with a mixture of rosin and paraffine oil is successfully used in one case and granulated cork soaked in pitch in another case. The waterproofing compound is necessary to prevent the moisture of the ground from being absorbed by the insulating material and thereby destroying its insulating value. Above ground all service lines must, of course, be insulated to and from the wall of the refrigerator. About all of the common forms of brine-pipe insulation are here represented.

There is little information on the loss of refrigerating power by reception of heat coming through the insulation of mains. This loss is constant on a given length of main for each division of temperature of the atmosphere, but varies directly (as to percentage of total load) with the load; that is, the greater the load the less the percentage of loss. Accurate thermometer readings of brine temperature in the mains at the stations and at various points on the line are needed to establish this interesting point. An attempt to arrive at it theoretically from the known insulating value of the covering would be frustrated by the unknown insulating value of the ground surrounding the insulation. It is suggested that careful research in this direction would be of great value.

Piping and fittings of various kinds have been used, both wrought and cast iron. In the latest installation (that at Philadelphia) a new form of cast-iron pipe was successfully installed. This pipe has at one end a slightly tapered boss, and at the other end an equally tapered recess both accurately machined. Bolt lugs are cast on the pipe near the ends. The taper is inserted into the recess, bolts are drawn up and the joint is complete and very tight. Owing to the fact that this joint under test showed great flexibility, it was at first thought that the joint itself would take care of expansion and contraction. This idea was quickly dispelled as soon as the brine was turned on, for the strain of contraction pulled off the lugs in several places. In further installation piston expansion joints were used at intervals of about 175 ft. and the trouble from broken joints ceased.

AMMONIA LINES.—Practically all of the ammonia lines have been laid under what has been termed the three-pipe system, consisting of a liquid line carrying the liquid ammonia under pressure by main and branch to the expansion valves at the refrigerators; a return or vapor line carrying back the gas; and a third line called the vacuum line. The expansion coils in the refrigerators are connected in multiple between the liquid and the vapor line. The vacuum line is connected at each expansion coil on the coil side of the stop valves on the liquid and vapor lines. Repairs at any refrigerator can thus be made without disturbing the balance of the system. The vacuum line is also connected at manholes for repair purposes on the main lines. It can be used as a bridge line to carry liquid over a block where there may be a leak on the liquid line. Its use is also imperative in extensions of existing lines to carry air or ammonia to test out new lines without disturbing the operation of old ones.

The ammonia lines are laid in a conduit of vitrified or salt-glazed split sewer pipe. The lower half of the conduit is first laid in concrete, then the ammonia lines are run and tested, then the top half of the conduit is laid on and cemented. Manholes are provided at street intersections in the usual manner of all street service work.

The expansion piping is rather liberally installed, the idea being to have enough piping to superheat the gas to nearly the temperature of the box and prevent frosting out into the return main. The patrol who handles the expansion valves acquires considerable skill in their manipulation, and as a rule is successful in holding the frost well inside of the refrigerator and allowing the gas to become so superheated that there is no frosting on the vapor service line leaving the refrigerator. In small refrigerators, however, it is very difficult to prevent frosting out, and wherever possible such boxes are connected in series with other boxes. Where a number of small boxes are grouped, as in a hotel or restaurant, a brine cooler fed from the street lines is installed, and brine circulation is used locally.

Laying out the central station as to tonnage of machinery and provision for increase involves a study of average weather conditions. The annual output must be divided into periods showing average demands by periods, and of course the plant must be machined for the highest daily load and for the absolute peak.

It has been found that the signal service temperature reports offer a scientific basis for forecasting the distribution of the load through the year for various localities, especially where (as is most often the case) the refrigerators in the distributing parish are directly affected by outside temperature conditions.

By taking the average mean monthly temperatures as shown by the Weather Bureau for a number of years and subtracting from each monthly mean the figure 32° (a little below freezing) the remainders will represent the distribution of the load by months. Working these figures into percentages of the total, we have our monthly load curve. Incidentally it may be said that these percentages indicate very clearly the relative monthly volumes of the sale of ice.

A study of figures deduced as above shows that the July and August averages are the greatest percentages of the total in north and diminish as we go south, where the curve flattens and the load is more evenly distributed throughout the year.

Absolute peaks are obtained by using the mean of the three hottest consecutive days which are given out by the Weather Bureau in their regular statistics.

For laying out piping for the distribution of liquid a drop in pressure between the condenser pressure and the pressure due to the highest temperature likely to exist at any point on the liquid line is to be taken as basis for friction head. Considerations of static pressure are also involved and must be taken into account. As most installations so far are on comparatively level ground, this latter item has not figured extensively, but it carries a limitation if liquid lines running to the upper stories of high buildings are involved. Such lines cannot be carried to a height where the loss of head would involve a pressure below the boiling point of the liquid at the temperature surrounding the pipe.

The temperature of the mains in the conduit seldom rises above 75° F. in the summer. This corresponds to an ammonia pressure of 126.5 lbs. With a condensing pressure of 150 lbs. the distribution of a given tonnage or its corresponding amount of liquid could be calculated on a drop of 23.5 lbs., but as it often happens that here and there liquid service lines run through warmer areas of temperature, it is not safe to rely on the temperature of the mains. In practice, therefore, a drop of 15 lbs. has been considered about the outside allowance for friction head. There always remains, in case of change of conditions, the alternative of raising the condenser pressure to keep the ammonia in liquid form up to the expansion valves.

Given the head as above, the problem resolves itself into one of hydraulics.

On the return side of the system the question of friction head is one of possible back pressures at the station and temperatures to be maintained at the farthest refrigerator.

It is manifestly desirable to hold the back pressure at the station as low as possible in order to obtain the greatest available friction head, thus keeping down the cost of line and also retaining the ability to give low temperatures at refrigerators far from the station and to keep down the cost of expansion piping. For this reason the absorption type of machine has been used largely for pipe line systems as it possesses the advantage of working with economy at low back pressures.

If a policy of avoiding freezing business at a distance from the plant is maintained (which is really only a small portion of the total demand) all other classes of refrigerators, say from 28° up, can be carried on the basis of 25 lbs. for the highest pressure on the return line and 5 to 10 lbs. at the station, giving a friction head of from 15 to 20 lbs.

An allowance of 15 lbs. for friction head is entirely safe under these conditions and the ordinary methods of figuring the flow of gases in pipes cover the case. This figure allows freezing business except on extreme ends of the line and permits a reasonable cost of piping both as to size of return line and amount of expansion piping.

In comparing the required tonnage with the space of refrigerated or with the insulated surface in the refrigerators, a wide variation of results is found. In small boxes the size of the box is not a governing factor as to tonnage; conditions of use, number of times of opening and closing, and many other items enter into the question. As most all street lines include the large with the small boxes, satisfactory averages are hard to obtain, since (as there are no individual meters) the total output of the machine can only be compared with the total space refrigerated.

Taking one plant, however, where the proportion of very small boxes is not large, some figures of interest can be presented. This plant supplies refrigerators ranging in size from 1,000 to 40,000 cu. ft., the average being 4,000 cu. ft. In July and August one ton of refrigeration takes care of 2,800 cu. ft. of space, or reckoning the area of the top, bottom and sides, one ton takes care of 1,128 sq. ft. of insulated area. One cubic foot of space requires .07 tons per annum. One square foot of insulation requires .204 tons per annum.

*An address before the American Society of Refrigerating Engineers at New York City, Dec. 4, 1905.

†President, Starr Engineering Co., 258 Broadway, New York, N. Y.

The most important question in direct-expansion pipe-line work is that of leakage of ammonia. In fact, experience has shown that the financial success of the system must stand or fall on this item. In the first installations a class of fittings was employed that were intended to give flexibility to the line and to allow for expansion and contraction. This system involved a construction whereby under expansion the line would tighten up on one set of packing and in contraction the line would tighten up on an opposing set. When lines were carefully laid, this system seemed to fully answer all requirements and for upwards of five years lines laid by this method remained fairly tight. After the expiration of that period, however, it became gradually apparent that the life of this class of joints was nearing the end. The continual motion of the line under varying pressures and the very large movement when ammonia was withdrawn for repairs and the pipe temporarily greatly reduced in temperature, brought alternate compression and release on these packings, their elasticity departed, and they were no longer effective. The leakage items became larger and larger until they reached a commercially dangerous point. To relieve this difficulty, expansion joints of the piston or U bend type were introduced, but they only partly solved the problem. Finally a system was adopted of anchoring the pipes at definite intervals with expansion joints at definite distance from each anchor, confining the expansion and contraction to definite distances and to calculable limits.

The later developments include welding the pipes in a continuous length from manhole to manhole and putting expansion joints at the manhole or U bends on the run. This seems to offer the most satisfactory solution of the difficulty and prevents the large item of leakage.

Of late apparently successful attempts have been made to weld the pipes in situ by the Thermit Welding Process. This method presents the great advantage of welding the pipe in their situation in the conduit and avoids the rather clumsy hand welding and handling of long lengths.

It seems assured that these methods will reduce the trouble from leakage to a satisfactory point and will confine all leakage to manholes where it can be readily detected and repaired.

While undoubtedly the major cause of loss from leakage has resulted from worn out or badly put together joints in the line, as a result of expansion and contraction, there will always remain a certain amount of what might be termed insensible leakage. By insensible leakage is meant that leakage which is extremely small when each case is referred to, but in the aggregate is an item to be reckoned with. This leakage is one so small that the ammonia quickly diffuses into the air, and it requires the closest "nosing" or a searching local chemical test to find it. While this will doubtless always exist, its aggregate will not be sufficient to cut a large figure in line expense.

THE TURBINE STEAMSHIP "CARMANIA" of the Cunard Line, the largest turbine-driven steamer in the world, arrived in New York on Dec. 11, completing her maiden trip across the Atlantic. The vessel has been put in service in remarkably quick time, as she only made her trial trip on Nov. 21. The steamer is a sister of the "Caronia" except in its machinery, the latter having twin screws and reciprocating engines, while the former has three screws driven by steam turbines of the Parsons marine type. The 'Carmania" is 675 ft. long, 72 ft. 6 ins. beam, 52 ft. deep, with loaded draft of 32 ft. (for 12,000 tons of cargo). The gross tonnage is 20,000, and the displacement is 29,800 tons. The three propellers are of bronze, 14 ft. diameter, with three blades, and run at about 180 revolutions per minute. The middle shaft is driven by a three-stage high-pressure turbine of 8 ft. diameter. Each of the side shafts has a three-stage combined low-pressure and astern turbine; these are 14 ft. diameter and 36 ft. long. The turbine blades are from 2 ins. to 7½ ins. long. All the shafts are 14 ins. diameter, and the central shaft is at a lower elevation than the side shafts. There are 13 Scotch boilers, fitted with the Howden hot-draft system; the boiler pressure is 185 lbs. and the steam enters the high-pressure turbine at 180 lbs. and the low-pressure turbines at about 90 lbs. There are centrifugal circulating pumps and double-cylinder dry-vacuum pumps, the vacuum being about 28 ins. The ship was built by John Brown & Co., of Glasgow. Two other turbine steamers, of much greater size and speed, and with four turbines and screws, are being built for the Cunard Line.

PIPE-THAWING BY ELECTRICITY has come into such extensive use in the past three or four winters that regular pipe thawing apparatus is now made and sold by the electrical manufacturing companies. The Westinghouse Electric Co. manufactures two outfits for this work, one a heavy duty apparatus consisting of a choke-coil used in connection with the primaries of a standard transformer, the other for lighter service, consisting of a small portable transformer weighing complete in its case about 100 lbs. This latter is intended for such work as thawing house piping or short service connections, while the larger outfit, being of 15 to 25 KW. capacity, can thaw street mains of some size.

A PIPE TUNNEL is to be built under the Milwaukee River at Milwaukee, Wis., to carry a 36-in. water main, taking the place of a similar main now laid in the bed of the river. It will extend from Poplar St. to Knapp St., with a total length of 345 ft. between the centers of the shafts. The depth is 52 ft. below water line (U. S. datum) at the Poplar St. shaft, and 55 ft. at the other end, while the Knapp St. shaft has a sump 4 ft. deep. The shafts are 7 ft. diameter, with 10-ft. openings to the tunnel, which is 7 ft. wide and 6 ft. 6 ins. high. Both shafts and tunnel will have a 12-in. (three-ring) brick lining. The tunnel has a semicircular roof of 3 ft. 6 ins. radius, and an invert of 6 ft. radius, with bottom corners of 1 ft. 11 ins., leaving 9 ins. of vertical to the springing line. The lining will be of good sewer bricks, all laid as stretchers and with toothed joints, the interior joints not to be more than ¼-in. and the collar joints not less than ½-in. The borings show sandy clay, sand and gravel, clay and gravel and hardpan. The work will be done by contract under the direction of Mr. Charles T. Poetsch, M. Am. Soc. C. E., City Engineer.

LARGE TANK LOCOMOTIVES of the 4:6:4 type for heavy suburban and other local service have recently been built at the J. A. Maffei Works, Munich, Germany, for the Madrid, Saragoss & Alicante Ry., of Spain. The line is practically level, of 5 ft. 6 ins. gage, and with sharpest curves of 590 ft. radius. The engines were specified to rapidly attain a speed of 40 miles an hour and to maintain this as an average speed. The cylinders are outside, with piston valves and the Walschaert valve-gear, and drive the middle axle. The firebox is of the Belpaire type, fitted between the frames. The tanks are on each side of the boiler, and the coal bunker is behind the cab. The weight on the trucks is carried by hemispherical side bearings, with no load on the center pin. The driving springs are below and the truck springs above the boxes, but no equalizing levers are used. The dome is placed at the extreme front end of the boiler barrel, and in the long smokebox the exhaust nozzle enters the base of a wire basket spark arrester, suspended below the base of the smokestack. The leading dimensions are as follows:

Driving wheels	5 ft. 0 ins.
Truck wheels	2 " 10 "
Wheelbase, driving	10 " 10 "
Wheelbase, each truck	6 " 3 "
Wheelbase, total	33 " 1 "
Length over buffers	43 " 4 "
Width over cab (extreme)	10 " 2 "
Weight on driving wheels	39 tons
Weight on each truck	17 tons
Weight, total	73 tons
Cylinders	17.6 × 25.2 ins.
Piston valves, diameter	9 ins.
Boiler, inside diameter	4 ft. 9 ins.
Boiler, rail to center line	8 ft. 6 ins.
Working steam pressure	175 lbs.
Dome, diameter	2 ft. 2 ins.
Tubes (Serve ribbed), No.	137
Tubes, length	13 ft. 5 ins.
Firebox, Belpaire	4 ft. × 7 ft. 4 ins.
Firebox, depth	5 ft. 4 ins
Heating surface, tubes	1,722 sq. ft.
Heating surface, total	1,850 sq. ft.
Grate area	30 sq. ft.
Smokestack, diameter	14.8 to 17 ins.
Smokestack, height from rail to top	14 ft.
Water capacity of tanks	8 tons
Coal capacity of bunker	3½ tons
Tractive power	10,400 lbs.

FIREPROOFED WOOD IN TALL BUILDINGS was the subject of an interesting veto-message by Mayor McClellan, of New York City, delivered on Dec. 12. At present the Building Code of that city requires that in buildings over 150 ft. high the interior finish and other woodwork shall be of "fireproofed" wood or metal-covered wood. An ordinance just passed by the Board of Aldermen, and supported by many persons interested in building work, aimed to amend this provision by permitting the use of hardwood as an alternative material. The ordinance was supported, for example, by the Building Trades Employers' Association, a strong organization of building contractors in New York City, by a resolution of its Board of Governors, which says, among other things, that

Whereas, This body has repeatedly expressed itself as being opposed to the compulsory use of so-called fireproofed wood, and

Whereas, There are many good and valid reasons why so-called fireproofed wood is disadvantageous to the building community and no apparently good reason why it is of advantage, it is hereby

Resolved, That this Board request the Legislative Committee of this Association to make every possible endeavor to bring before the Board of Aldermen and the Mayor of this city the reasons why the compulsory use of fireproofed wood should be stricken from the Building Code.

The ordinance was duly passed by the Board of Aldermen, but the Mayor has now vetoed it, with the following remarks:

This proposed change is a most important one, and it should be considered with the greatest care and caution. For the past six years the city has required the use of fireproof wood in buildings of a certain character, and to now reverse its former policy and abolish these requirements would, in my opinion, be a serious mistake, unless it can be shown with reasonable certainty that nothing can be gained by a continuance of its use.

I know of no good reason at present for wholly condemning the use of fireproof wood. While I am aware that it has been pronounced a failure by some, yet there are many who contend that its use safeguards life and property to a very great extent. Indeed, only last year your own board passed an ordinance, which I subsequently vetoed, extending the compulsory use of fireproof wood to buildings of 100 feet in height. If it was your opinion a year ago that the further use of fireproof wood was highly desirable, I see no reason why you should now approve of its elimination.

The whole question is too serious a one, in my opinion, to be disposed of without a thorough examination into the merits of the proposition. A full hearing should be given to those interested in the matter, and, if necessary, tests should be made and testimony of experts taken, to the end that a decision may be reached which shall be based upon proof, rather than on mere speculation.

While dealing with this subject, I desire to call the attention of the Board to the fact that there are many existing inconsistencies in the Building Code which should be corrected, and that many of its sections are in great need of revision. I think it most desirable that these matters should be taken up and considered at the earliest possible moment. To this end I advise—if these views meet the approval of your Board—that authority be given to me to appoint a commission to inquire into these matters, and to prepare for submission to your Board a revision of the Building Code, which may meet the needs of the present day.

It is to be hoped that the proposed commission to revise the Building Code may be soon authorized.

OF CANADIAN IMPORTS DURING 1904-5 the United States supplied 62%, or about $166,000,000 out of $277,000,000. The goods exported from the United States to Canada were 11% of the total exports of the former country. A large part of the rapid growth of the Canadian Northwest is due to immigration from the United States, which began to a notable extent in 1888-9, when 12,000 persons from this country crossed into Northwestern Canada. In 1903 no less than 49,473 of the 128,364 immigrants into that section were from the United States, but since then the proportion has declined. The foregoing statements have been taken from an extended report on the resources and development of Canada and its trade relations with the United States, by Mr. Chas. M. Pepper, Special Agent of the Bureau of Manufactures, U. S. Department of Commerce and Labor, published in Daily Consular and Trade Reports for Nov. 27, 1905.

PERSONALS.

Mr. Geo. L. Campen, City Engineer of Lincoln, Neb., has been appointed Water Commissioner for the Panama Canal Zone.

Mr. R. G. Butler has been appointed Manager of the Grand Trunk Milwaukee Car Ferry Co., with office at Milwaukee, Wis.

Mr. Richard C. Huston has been elected City Engineer of Hattiesburg, Miss. Mr. Huston's new position will not interfere with his consulting practice.

Mr. J. W. Mulhern has been appointed Superintendent of the Galesburg Division of the Chicago, Burlington & Quincy Ry. Co., in place of Mr. R. L. Porter, resigned.

Mr. Franklin Lane, of California, has been nominated by the President as a member of the Interstate Commerce Commission, to succeed Commissioner J. W. Fifer, resigned.

Mr. Charles R. Olberg, Assistant Engineer in the Reclamation Service, has resigned to enter on duty by transfer in the Quartermaster's Department at large, U. S. A.

Mr. H. W. Baker, Assistant Engineer with the Chicago & Northwestern Ry., has been appointed Professor of Civil Engineering at the Nevada State University at Reno.

Mr. W. J. Underwood, Assistant General Manager of the Chicago, Milwaukee & St. Paul R. R., has been appointed General Manager, succeeding Mr. H. R. Williams, resigned.

Mr. Robert S. Clemons, formerly with the Crocker-Wheeler Co., has become associated with Dodge & Day, Philadelphia, and will devote himself especially to power-house construction.

Mr. Horace Baker, Assistant General Superintendent of the Southern R. R., has been appointed General Superintendent of the Missouri Pacific R. R., to succeed Mr. W. T. Taylor, resigned.

Mr. Thomas R. Means, Engineer of Soils of the U. S. Reclamation Service, has been ordered to Snyder, Oklahoma, to begin an examination of the soils and water supply of the Red River project.

Mr. George H. Daniels has been placed in charge of the General Advertising Department, just organized by the New York Central R. R., with headquarters at the Grand Central Station, New York City.

Mr. George A. Clark, formerly vice-President and General Manager of the Tennessee Central R. R., has been appointed vice-President and General Manager of the Colorado Southern, New Orleans & Pacific R. R., a projected line, with headquarters at New Orleans, La.

Mr. W. T. Dorrance has resigned his position with Westinghouse, Church, Kerr & Co., New York, and has accepted a position with the engineering department of the New York Central & Hudson River R. R., with headquarters at 335 Madison Ave., New York City

Mr. Thomas F. J. Maguire, Electrical Engineer of the Navy Department, has been detailed by the Bureau of Yards and Docks, to take charge of the large power plants in the various Navy Yards. Mr. Maguire is a native of Boston and a graduate of the Massachusetts Institute of Technology.

Mr. I. A. McCormack, Manager of the "Harlem Line" of the New York Central & Hudson River R. R., has had his jurisdiction extended from Mott Haven to High Bridge on the Hudson Division and to Wakefield on the Harlem Division. His title is General Superintendent of the Electric Division.

Mr. J. D. Trammel, Chief Engineer of the Great Northern Ry., has been given leave of absence, on account of sickness in his family, and the office of Chief Engineer has been abolished. Mr. O. W. Crittenden has been appointed Resident Engineer in charge of the Engineering Department.

Mr. Ernest C. Howard, Resident Engineer of the Sixth St. Viaduct, Kansas City, Mo., has recently issued unique invitations to what is called "An Informal Compressed Air Smoker." It is to take place 40 ft. below the surface of the Kaw River, in the Air Chamber of the Caisson for Pier No. 2.

Mr. C. F. Daly, Passenger Traffic Manager of the New York Central Lines, west of Buffalo, has been appointed to a similar position for the lines east of Buffalo, with headquarters at the Grand Central Station. Mr. Warren J. Lynch, at present with the Big Four R. R., takes the position Mr. Daly is leaving.

Mr. Robert Moore, Member and Past-President Am. Soc. C. E., has been elected Consulting Engineer of the St. Louis Municipal Bridge and Terminals Commission. Mr. Moore's experience and his long acquaintance with the railway terminal problems of St. Louis make him eminently fitted to act as expert for this Commission.

Baroness von Suttner, of Austria, has been adjudged winner of the Nobel Peace Prize. For many years the Baroness has been prominent in international movements looking to the peace of the world. The other four Nobel prizes were won by Prof. Philipp Lenard, of Kiel University, in Physics; Prof. Adolph von Boeyer, of the University of München, in Chemistry; Prof. Robert Koch, of Berlin, in Medicine; and Sienkiewicz, the Polish novelist, in Literature.

Mr. John D. Isaacs, M. Am. Soc. C. E., has been appointed Consulting Engineer for the completed lines of the Union Pacific R. R., Oregon Short Line R. R., Oregon Railroad and Navigation Co., and Southern Pacific Co., in all matters relating to construction and maintenance of bridges and buildings, signaling and preservation of timber, with headquarters at San Francisco, Cal. Mr. Isaacs was formerly Bridge Engineer and Assistant Engineer of Maintenance of Way of the Southern Pacific R. R.

Obituary.

William Chisholm, Sr., a retired steel manufacturer of Cleveland, O., died of apoplexy at the age of 62.

Henry R. Sloat, Assistant Secretary and Treasurer of the Tennessee Coal, Iron and Railroad Co., died suddenly this week at his home at Sloatsburg, N. Y. Mr. Sloat was about 70 years old.

Nelson F. McClary, a recent graduate of the Thayer School of Engineering, died Nov. 28 at Guayaquil, Ecuador. Mr. McClary was with a party of American Engineers making a preliminary railroad survey from Ambato to the headwaters of the Amazon in the "Oriente."

Thomas G. Smith, M. Am. Soc. M. E., one of the leading Civil, Mechanical and Architectural Engineers of Cincinnati, died Nov. 21, after an illness of eleven months. The immediate cause of death was tumor on the brain. Mr. Smith was born in Cincinnati March 19, 1862, and spent most of his life in this place. He was a graduate of Stevens School of Technology.

Charles Stoughton, who has been greatly interested in the improvement of the water-ways traversing the northern parts of New York City, died Dec. 1 in his ninetieth year. Since the late '70's he has kept alive the scheme of making the Harlem River and Bronx Kills navigable, and through his personal efforts secured appropriations from Congress for doing this work.

Gabriel Leverich, M. Am. Soc. C. E., well known in connection with his work as Assistant Engineer on the Brooklyn Bridge, died at his Brooklyn residence, 815 Park Place, Nov. 28. Mr. Leverich was a graduate of the Rensselaer Polytechnic Institute in the class of '57, and in the following years was engaged in ordnance work and bridge construction. In 1878 he joined the engineering staff at work on the Brooklyn Bridge, and for the succeeding 22 years showed untiring zeal in his work of construction and maintenance. His chief work was in the development of the cable driving plant and design of the terminal stations. In 1870 Mr. Leverich was elected a Member of the American Society of Civil Engineers, and served as its secretary from 1872 to 1877, at a time when the Society was experiencing a rapid growth. Mr. Leverich was about 70 years of age. For the past six years he had been out of active engineering practice, owing to ill health.

Edward Atkinson, President since 1878 and one of the founders of the Boston Manufacturers' Mutual Fire Insurance Co., died on Dec. 11 of heart trouble, attributed to an acute attack of indigestion. Mr. Atkinson was born in Boston on Feb. 10, 1827. At fifteen he entered a Boston commission house, where he remained five years. He was subsequently connected with various manufacturing companies. Mr. Atkinson was the author of a long list of books and pamphlets on fire prevention, cotton manufacturing, railroading, finance, free trade, anti-imperialism and other subjects. He was also the inventor of the "Alladin Oven." Quite recently he had taken great interest in what he called "Bog Fuel," reading a paper on the subject before the New England Water-Works Association a year or so ago. At the time of his death Mr. Atkinson was a director of the Massachusetts Institute of Technology, a member of the American Academy of Arts and Sciences and of various other scientific or statistical bodies. The degree of LL. D. was conferred on him by the University of South Carolina and of Ph. D. by Dartmouth, and he was elected as an honorary member of Phi Beta Kappa (Harvard University).

ENGINEERING SOCIETIES.

COMING MEETINGS.

ENGINEERING ASSOCIATION OF THE SOUTH.
Dec. 15, 16. Annual meeting at Birmingham, Ala. Secy., H. M. Jones, Berry Block, Nashville, Tenn.

AMERICAN ECONOMIC ASSOCIATION.
Dec. 27 to 29. Annual meeting at Baltimore, Md. Secy., F. A. Fetter, Ithaca, N. Y.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 29 to Jan. 4. Annual meeting at New Orleans, La. Secy., L. O. Howard, Washington, D. C. Secy. of Section D (Mechanical Science and Engineering), Prof. W. T. Magruder, Columbus, O.

MICHIGAN ENGINEERING SOCIETY.
Jan. 9, 10, 1906. Annual convention at Lansing, Mich. Secy., F. Hodgman, Climax, Mich.

NATIONAL ASSOCIATION OF CEMENT USERS.
Jan. 9 to 12, 1906. Annual convention at Milwaukee, Wis. Secy., C. C. Brown, Commercial Club Bldg., Indianapolis, Ind.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Jan. 10. Annual meeting at Boston, Mass. Secy., Willard Kent, Narrangansett Pier R. I.

NORTHWESTERN CEMENT PRODUCTS' ASSOCIATION.
Jan. 17, 18, 19. Annual convention at Minneapolis, Minn. Secy., F. H. Chapin, 10 N. Third St., Minneapolis, Minn.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 17, 18, 19. Annual meeting at Rockford, Ill. Secy., E. E. R. Tratman, 1636 Monadnock Block, Chicago.

INDIANA ENGINEERING SOCIETY.
Jan. 18, 19, 20. Annual meeting at Indianapolis, Ind. Secy., C. C. Brown, Commercial Club Building, Indianapolis, Ind.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Feb. 21. Annual meeting at South Bethlehem, Pa. Secy., R. W. Raymond, 99 John St., New York, N. Y.

WESTERN SOCIETY OF ENGINEERS.—On Dec. 2 a large party of members accepted the invitation of the Illinois Steel Co. to visit its Portland cement plant at Buffington, Ind. At the regular meeting held at the Society's rooms in Chicago on Dec. 6 Mr. C. E. Sargent presented a paper on "The Prime Mover of the Future," dealing with the past, present and future of the gas engine. A number of illustrations were given of modern high-power gas engines.

THE TECHNICAL PUBLICITY ASSOCIATION.—Mr. Rodman Gilder, Secretary of this recently formed society, sends us the following article respecting its object and aims: One of the remarkable developments in modern industrial life is the rise of the Manager of Publicity. It is not long ago that he was a mere clerk, whose principal duty was to try to persuade advertising canvassers to cut prices and split commissions. Little else was expected of him, except to keep track of the cards carried in the various magazines, and hunt the printer when the annual catalogue was being put through the press.

The methods of advertising, the choice of mediums, etc., were taken care of, after a fashion, usually by some officer of the company, who considered all his other duties more important.

Nowadays the Manager of Publicity not only has a sonorous title, but has duties and opportunities that are almost without limit. He must first of all be a sort of auxiliary general sales manager, and must know what is going on in the field. Then he has to keep in touch with the factory and with the engineering department and know what each is doing. He must [illegible] on all the methods by which his commodity [illegible] vertised. He must be a judge of photo[illegible] tones, line cuts, presswork, paper, ink, [illegible] lay-out, English and advertising solicitor[illegible] cially must he have a due regard for the [illegible] of his own position.

This respect for the work they are doing [illegible] that brings together once a month the me[illegible] Technical Publicity Association. The obj[illegible] recently formed club of publicity manage[illegible] friendly interchange of ideas; the presenta[illegible] members and guests of discourses upon v[illegible] bearing upon matters relating to the advert[illegible] ment; and the general study of all matter[illegible] to the advancement of the art of publicity."

Any "man or woman filling the position [illegible] ing manager in any concern engaged in the [illegible] of machinery, or in any concern which [illegible] fully come under the head of an 'allied ind[illegible] any one assisting in the advertising departm[illegible] concern, is eligible for membership. These r[illegible] have been lived up to so carefully that the A[illegible] has lost three of its founders, who have op[illegible] their own offices as consulting experts in publicit[illegible]

One of the most useful services within the [illegible] of the Association is the investigation of the [illegible] claims of the trade and technical magazine[illegible] A circulation committee has recently been appointed to take up this elusive subject.

The officers of the Technical Publicity Asso[illegible] are the following: President, C. B. Morse, Ingersoll-Rand Drill Co., New York; 1st vice-President, H. M. Weaver, Niles-Bement-Pond Co., New York; 2d vice-President, F. H. Gale, General Electric Co., Schenectady, N. Y.; Secretary, Rodman Gilder, Crocker-Wheeler Company, Ampere, N. J.; Treasurer, H. M. Davis, Sprague Electric Co., New York; Members of Executive Committee, Chas. N. Manfred, Johns-Manville Co., New York; F. S. Wayne, Robins Conveying Belt Co., New York.

CONCRETE ASSOCIATION OF NEW YORK.—Several weeks ago there was reported in this column a meeting held in New York City by local builders, engineers and others interested in concrete construction for the purpose of forming an organization, semi-technical in character, for the advancement of the concrete industries. At that meeting temporary officers were elected, and a committee of six was designated to draft a constitution. On the evening of Dec. 8 the second general meeting was held at the rooms of the Building Trades Employers' Association, 1123 Broadway, New York, under the chairmanship of Mr. R. F. Tucker (Tucker & Vinton, Inc.), who had been elected president at the first meeting. The draft of a constitution was submitted by Mr. H. C. Turner (Turner Construction Co.), for the committee; the draft was in excellent and thorough form, and with minor changes was adopted as the constitution of the new organization. According to this document the name of the organization is "The Concrete Association of New York," whose purposes are thus stated:

> The object of this association shall be to encourage and develop the intelligent and scientific use of cement, concrete and steel reinforcement, concrete machinery, to standarize methods of construction with a view to obtaining best results, to promote social intercourse and to secure an exchange of views upon subjects of interest, to reform abuses relating to the various industries represented by the membership of the association, to obtain and diffuse accurate and reliable information relating to all matters affecting the concrete industry, and to establish and maintain a permanent exhibition of its various products and manufactures.

Three classes of membership are provided to carry out these extensive purposes: Active, Associate, and Honorary. The Active class, which monopolizes the voting and office-holding privilege, is to include:

> Any individual, firm or corporation whose capital is invested in the business of manufacturing cement, cement and concrete construction, reinforcing material, concrete machinery, or whose business is directly allied with the concrete industry.

The Associate class is intended to take in all who are not eligible to active membership, but who take an interest in the work of the association. Annual dues of $40 for active and $16 for associate members are specified, and initiation fees of $50 for active ($25 for the first 100 active members) and $10 for associate members. During the discussion of the provisions of the constitution, before its adoption, an effort was made to exclude manufacturers of cement from the active class, or at least to leave them the option of entering either the active or the associate class of membership. This effort failed, however, and under the constitution as adopted specifications for active membership are as above quoted, and the associate class is open only to those not eligible for active membership.

Meetings of the new association will be held monthly, on the evening of the second Tuesday. The January meeting is the annual meeting, at which officers (President, three Vice-Presidents, Treasurer, Secretary) are elected. Under the present temporary organization Mr. R. F. Tucker is President and Mr. T. G. [illegible] is Secretary.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, December 14, 1905.

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After some months of work by an expert indexer, in cooperation with the editorial staff of this journal, we are able to announce a General Index to Engineering News, 1900 to 1904. This classified five-year index follows the same lines as the one issued a few years ago for the ten years from 1890 to 1899, inclusive, but the new index is nearly as large as the one for the earlier period. This is due to fuller indexing and also to an increase in the number of articles published of late. Together the two indexes cover 30 half-yearly volumes of Engineering News, in which may be found a record of a large part, and that the best part of the engineering work and thought of the last fifteen years. The usefulness of these consolidated indexes to the busy man is so obvious as to need no comment from us.

Not every engineer has a file of Engineering News for the past ten years, or even for the last five years, but in all the larger and in many of the smaller cities files extending through many years can be found. Some of these are in city or college libraries, and, therefore, for the most part, accessible to anyone; more are in private libraries, and so, in theory, not generally accessible. We venture to say of the last that there are but few engineers who would not gladly extend the use of their files of this journal to their fellow engineers. For the convenience of our readers we should be pleased to be informed of the existence of files of bound volumes of this journal that are available for general reference purposes. This information may come from the owners or from others who know of the existence of available files. If we can secure a sufficiently long list to make it worth while we will attempt to make it available to our readers.

Smiles' "Lives of the Engineers," reviewed in our issue of Oct. 12, 1905, is sold in this country for $1.25 per volume, or $6.25 per set, both net, instead of $1.40 per volume, as there stated. We make this statement both to correct an error and to call attention once more to these interesting lives of twelve early engineers, the names of whom will be found in the issue of this supplement mentioned above. The set, or any volume of it, would make a fine Christmas present to a young engineer or engineering student; or for that matter, to any engineer, young or old.

From time to time our British contemporaries express a fear or admit the possibility that this country will take the lead in technical literature. An expression of this sort, relating to the "Transactions" of the British Association of Water-Works Engineers, was published in our issue Dec. 15, 1904 (page 469).

In somewhat the same vein the London "Architect" of Oct. 20, 1905, in reviewing L. C. Sabin's "Cement and Concrete," says:

> Unless care is taken there is a likelihood that Americans will monopolize technical literature in the English language, and more particularly whatever relates to construction. English architects and engineers are singular in their indifference to books. A few may be occasionally kept in an office for show, but as a rule there is an absence of treatises or records. It might be imagined their clients considered that practical skill does not co-exist with respect for experience as represented in books. In the United States, on the contrary, there is at least as good a market for English technical books as in England. French publishers, who cannot be persuaded that there is any sale for technical treatises in England, rely on American purchasers, although an absurd duty is levied on imports. American books can be as easily comprehended by Englishmen as by Americans, and as there is no duty as an obstacle to their introduction, it is not unlikely that an effort will be made by the publishers to secure the sale, although it be only limited, of their books in this country. That might be no great gain to them. But it is well to remember that technical books are not like novels. They deal with materials, machinery and processes which it may also be considered desirable to obtain for English use, as well as the services of the architects, engineers or other experts who have had charge of the works described. We may, in fact, look on the books as if they were pioneers to open out a way in a country where there is too much supineness as a consequence of an exaggerated belief in capabilities.

A part of "The Architect's" favorable comment on the book already mentioned may be given, as it contains some plain expressions of opinion regarding British books on concrete:

> It must be said that the American books deserve success owing to the care and labor taken in their production. The treatise on cement and concrete by Mr. Sabin is an example. An Englishman who uses either cement or concrete would be likely to say that it was a waste of paper and ink to occupy 500 pages with such a subject. A few notes are supposed to be sufficient data. The position of Englishmen with regard to cement and concrete is suggested when we find that there are only two or three references to experiments which were made in this country. A stranger would suppose that among us there is no knowledge of either material.

Whatever may be one's opinions as to the likelihood that America will lead Great Britain in technical literature it is unquestionably true that many of the European books that reach this country seem to be woefully deficient as guides to modern practice. One of the worst faults of some of the foreign books is their categorical descriptions of methods or machines regardless of whether in use or not, or if in use, whether they possess practical value. British authors seem to be the greatest sinners in this respect, the French next, and the Germans least. Curiously enough, though, in this very issue of the Supplement, a German book is noticed (Schnabel's "Metallurgy," reviewed by Professor Stoughton), which the reviewer states abounds in descriptions of abandoned processes. As the reviewer says, explanations of the causes of abandonment would be helpful, but usually the author did not even state that the processes are no longer in use. We do not claim that American books are free from just such dead matter, but we think they give less offense of the sort than do British and perhaps French books.

While on the subject of foreign books mention may be made of a great drawback to translations of technical books into other languages; the length of time that usually elapses between the writing of the original and the appearance of the translation. In these days of rapid changes in the industrial arts a technical book is often out of date as soon as off the press; how much more behind the times is its translation! Quite recently the second German edition of an expensive technical book was actually received in this country a few weeks after the publication here of an English translation of the first German edition. The American edition of Schnabel's book, already mentioned, suffers from the translation of American writings for use in the German edition and their retranslation into English for the edition in that language. But after all that has been said we welcome the foreign books—British, French and German—and shall rejoice if no graver criticisms are justly made of such American books as find a reception abroad.

REVIEWS.

Copper, Lead, Silver and Gold.

Reviewed by Bradley Stoughton.*

HANDBOOK OF METALLURGY.—By Dr. Carl Schnabel, Konigl. Preuss. Ober-Bergrath Professor of Metallurgy. Translated by Henry Louis, M. A., A. R. S. M., F. I. C., etc., Professor of Mining at Armstrong College, Newcastle-upon-Tyne. Second Edition.—Vol. I. Copper—Lead—Silver—Gold. London: Macmillan & Co., Ltd. New York: The Macmillan Co. Cloth; 6 x 9 ins.; pp. 1,123; 715 figures in the text. $6.50.

For the scheme of this book we may best refer to the words of the Translator's Preface, as follows:

> It is a curious fact that there does not exist in the English language a single complete treatise on metallurgy.
>
> The object of Dr. Schnabel's work has been to give a complete account of the metallurgical treatment of every one of the metals ordinarily employed (except iron), together with all the recent improvements in the art, whilst at the same time pointing out the scientific principles underlying each process, and illustrating each by examples drawn from actual practice in various parts of the world.
>
> The work is divided into two volumes. The first embraces the metallurgy of copper, lead, silver and gold. . . . The remaining metals are treated of in volume 2, the most important among them being zinc, nickel and mercury.
>
> The second English edition, of which the first volume is now issued, is a translation of the second German edition, the first volume of which was brought out by Dr. Schnabel in 1902, and which brought the subject of which he treats thoroughly up to date. The second volume of the translation, the original of which was published in 1904, will, I hope, be ready in 1905. The translation has been performed with the same exactitude as was that of the previous edition, literary style being throughout subordinated to literal accuracy.

From the reviewer's viewpoint it is regrettable that Vol. 1 has appeared independently of Vol. 2, because there is so much to be criticised in Vol. 1 and its reason for being is comparatively so small, whereas we know, from the study of the former edition, that Vol. 2 will give us much to praise and is of vastly greater importance. The literature of copper, lead, silver and gold is abundant and admirable, while the minor metals have not been so thoroughly treated.†

The publication of this book will supply a de-

*Adjunct Professor, Department of Metallurgy, Columbia University, New York City.

†To supply information to those who may be interested, and to satisfy a demand of which the reviewer is well aware, through numerous letters of inquiry which he receives every year, the following list of the leading books on the subjects is appended:

COPPER.—Modern Copper Smelting. E. D. Peters, M. D. 7th edition, 1905. New York.
Modern Electrolytic Copper Refining. Titus Ulke. 1903. New York.
Notes on Lead and Copper Smelting and Copper Converting. H. W. Hixon. 1897. New York.

LEAD.—The Metallurgy of Lead and Desilverization of Base Bullion. H. O. Hofman, E. M., Met. E., Ph. D. 5th edition. 1899. New York.

SILVER.—Metallurgy of Silver. Henry F. Collins. 1900. London.

GOLD.—The Metallurgy of Gold. T. Kirke Rose, D. Sc. 4th edition. 1902. London.
Cyanide Practice. Alfred James, E. M. 1902. New York.

ZINC.—The Metallurgy of Zinc and Cadmium. Walter R. Ingalls. 1st edition. 1903. London.
Metallurgie du Zinc. A. Lodin. 1905. Paris.

ALUMINIUM.—Aluminium. Joseph W. Richards, A. C., Ph. D. 3d edition. 1896. Philadelphia.

NICKEL.—Le Nickel. Henri Moissan et L. Ouvrard. 1898. Paris.

mand on the part of those whose affairs necessitate much travelling and the transportation with them of as much information on metallurgy as they can conveniently carry. If a metallurgist is travelling through Mexico or South America, much of his progress being accomplished on mule-back, and his baggage as limited as possible, he is liable to come across a "proposition," as they say in the West, necessitating the choice of the best process by which to treat an ore for either copper, lead, gold, silver, nickel, zinc, cobalt, etc. He cannot carry detailed information on all the methods in his head and it is very serviceable to him to be able to refer to information which will assist him in an intelligent choice and to make a start at treatment. The information is here, though not in as systematic and good form as it might be.

For each of the four metals the book begins with a discussion of the physical and chemical properties and behavior. Then follows a description of the ores and a condensed statement of the processes of extraction, concluding with detailed information on the processes and apparatus, illustrated by examples from practice. Probably the worst errors in the book are found under the head of physical properties. The figures given are, in almost every case, a long way out of date, and worthless for current use. If the writer had given us the exact reference so that the original source could have been consulted the figures might have been of some value, but in no case does he quote anything more than the name of the investigator, leaving the reader to make his own researches as to the source. A single example of these inaccuracies will serve as an illustration: On pages 1 and 578 he gives the electric conductivity of copper (silver being 100) as 93.08 and 72 to 77, respectively. In neither case does he state what degree of purity the copper had, nor assist us in obtaining this information for ourselves. The correct figure is about 100, from latest researches. This refers to chemically pure copper, the effect of traces of foreign bodies being extremely important in this connection, as Professor Louis must be aware.

The chemical reactions and descriptions of ores are good and appropriate, since a handbook might be most useful for field work. The descriptions of the various wet processes of extraction are also valuable, as this is the one subject on which our literature is still too meager, except in the single case of treatment of gold ores.

The treatment of roasting, under the head of copper, is good, but not as much so as the corresponding section of Ingalls' book (see foot note). A special feature is the descriptions of shaft furnaces for roasting. The mechanical furnaces are not so good, too much space being wasted on furnaces which have proved to be failures (e. g. the Keller-Gaylord-Cole), and some of the best recent American furnaces not being mentioned (e. g. the Klepetko). There are several errors in this section also, as to the relative advantages of the different types. There are two other errors under the copper chapter which are annoying, if not very important: One is that Root's blowers (an American machine) are used in Europe, but not in America (page 117. It is contradicted on page 468). The other is the several references to the Nichols Chemical Works as the "Nicholson Works" (pages 138, 222).

There is one error under the chapter on lead which especially requires correction: On page 440 it is stated that rotating cylinder roasting furnaces are only rarely used for lead ores. At the time Dr. Schnabel wrote this edition this particular type of furnace was used more than any other in the United States, and it has continued to be one of the most important, though not as much so as it was. The description of German lead smelting is good for us to hear about, and is a valuable feature of the book.

The chapter on silver has a great deal more space than the relative importance of its treatment, separate from lead and copper, deserves. The waste of space occurs in the discussion of the wet processes, many of which should have been omitted altogether, as they died long ago. The very important question of the parting of gold and silver is treated all too briefly, especially the electrolytic treatment, which demands particular attention. The electrolytic refining of copper is also too vaguely described, and references to current literature are wanting.

One weakness which especially limits this book as a handbook is the very indefinite and perplexing manner in which the various processes for the treatment of ores are compared; referring, for illustration, to pages 17, 23, 25, 120, 160, 423, 542, 624, 627, 664, 743, 928, etc. Space does not permit of further discussion of this point, but the weakness is increased by two facts: The book abounds with descriptive detail of processes old and new, dead and alive. Those processes which are dead have been abandoned for good and sufficient reasons. The statement of these reasons would indeed have clarified our ideas, but not only are they usually wanting, but, in many cases, the fact is not even recorded that the process is no longer in use. In the preface Dr. Schnabel says:

> Since a knowledge of a development of metallurgy from the earliest periods is of especial value to the metallurgist, and more particularly in stimulating the inventive genius, particular attention has been devoted to the older metallurgical methods and appliances.

I cannot agree with Dr. Schnabel in his reasons. A handbook of metallurgy is not calculated for the purpose of stimulating inventive genius, or for treating the history of the subject. These things are distinctly in the scope of the library reference works. If he had omitted them from the handbook, he would have avoided clouding the main issue of the very important comparisons, and would have permitted more space to be devoted to the principles underlying the various processes, and philosophical discussions of them. The lack of the philosophical tendency throughout the entire book is the second agency increasing the weakness of the comparison of methods. In reading the book one is continually looking for the "why."

In this same connection should be mentioned a constant timidity in expressing opinions. One example will serve to illustrate many others: On page 145 he says: "Heap roasting of matte is best carried out under shelter to prevent the sulphate of copper being leached out by rainwater." He should have said "must be" instead of "is best." His statement is safe and technically correct, but might well be a pitfall to the inexperienced or impulsive man.

For these and other reasons it is open to question whether this book has a right to its title of "Handbook of Metallurgy," because, in the first place, it is only a handbook of non-ferrous metallurgy, the most important of the metals, iron and steel, not being included. In the second place it does not include practically anything more than a description of the extraction of the metals from their ores, that very important branch of metallurgy, the adapting of metals to practical use, the principles underlying the beneficial and injurious effects of foreign bodies, the theory of metallic alloys and solutions, not being treated for any of the metals. This branch of metallurgy is the one which is now attracting the greatest amount of attention from scientists and practitioners. Nevertheless, even where it enters very prominently into the extraction of metals, as, for illustration, in the Pattinson and the Parkes processes, the author has ignored it.

Finally a handbook, by definition, should be brief and make the utmost use of available space, whereas here a great deal of valuable space has been wasted in the translator's effort to preserve German equivalents. Throughout the book, line after line has been taken up by parentheses which include the German word of which the English text is a translation. For illustration take pages 238 et seq. This is an utter waste of valuable space for which no reasonable excuse can exist. The English words, "tough-pitch copper," "litharge," etc., are thoroughly well-known in the trade. The advantage of placing their German equivalents in parenthesis next to them is wholly visionary. There is just as much reason for the French equivalents to be there, which would make the literary comparison complete. But certainly a handbook should be the last place in which space is to be sacrificed to literary effort.

In another respect the book represents a very regrettable loss of energy: A very large share of the 369 pages devoted to copper is taken from Peters', and much of the 200 pages on lead is likewise from Hofman (see footnote). The chapter on gold (170 pages) is also largely drawn from English works of Egleston, Rose, the Transactions of the American Institute of Mining Engineers and the Mineral Industry. We thus see the double labor of translating these English works into German by Dr. Schnabel, and their re-translation into English by Professor Louis, after some of their value has been destroyed by the lapse of years.

If the data were only up to date, the book would form an excellent text-book for students of metallurgy. At the present time the demand on a students' purse is very heavy, since he must supply himself with separate text-books on the subject of iron and steel, copper, lead, gold and silver, and all of these condensed into two volumes would indeed be a saving, besides which he would have for reference the metallurgy of zinc, aluminum and the minor metals.

POOR'S MANUAL OF THE RAILROADS OF THE UNITED STATES.—Street Railway and Traction Companies, Industrial and Other Corporations and Statements of the Debts of the United States, the Several States, Municipalities, etc. Thirty-eighth Annual Number, 1905. New York: Poor's Railroad Manual Co. London: Effingham Wilson. Cloth; 6 × 9 ins.; pp. 1,724 + xv.; folding and other plates. $10.

POOR'S DIRECTORY OF RAILWAY OFFICIALS.—(Steam, Electric and Other). Containing Lists of the Officials of all the Railroads in Operation in the United States, Canada and Mexico. Edition of October, 1905. A Supplement to Poor's Manual of Railroads. Nineteenth Year. New York: Poor's Railroad Manual Co. Stiff paper; 6 × 9 ins.; pp. xxxiv. + 168. $2.50.

The year 1904 is covered by this well known and indispensable Manual. Of the 212,349 miles of railroads completed on Dec. 31, 1904, reports of "traffic statistics, gross earnings, etc., complete," are included, which is certainly a remarkable showing. Street railways are also fully reported on, and the leading financial statistics of the United States and the several states seem to be complete. The financial statistics of cities and towns appear to be as complete as could be expected, for the municipalities included, but to keep the volume anywhere within bounds of course minor towns have to be omitted.

The directory contains a list of railways doing a general traffic business, a separate list of street railway companies, arranged by States, and also a list of Purchasing Agents, Master Mechanics and Chief Engineers.

EXPORTERS' ENCYCLOPAEDIA.—Containing full and authentic information relative to shipments for every country in the world. New York: Exporters' Encyclopaedia Co. Cloth; 5½ × 8¼ ins.; pp. 508. $3.

General shipping instructions, values of foreign coins, a table of equivalents of pounds and kilograms, and a long index of countries, ports and inland points, are followed by concise instructions, regulations, etc., for shipping to different countries and by different lines, the names and addresses of the latter being given. New York leads in the space given to it, but other Atlantic and some Gulf ports are included. Lists of foreign consuls at the various American shipping ports listed are given and also examples of consular invoices to South American countries.

BULLETINS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 6 × 9 ins.

No. 270: The Configuration of the Rock Floor of Greater New York. By William Herbert Hobbs. Pp. 96; five plates and six text illustrations.

By an examination of records and by interviews with engineers and others the author has collected much valuable information on the depth and character of the bed rock which underlies New York City. The information so collected is here presented by means of maps, diagrams, tables and text, and promises to be of great value to engineers and builders.

Locomotive Handy-Book.

Reviewed by Arthur M. Waitt.*

MODERN LOCOMOTIVE ENGINEERING.—With Questions and Answers. A Plain, Practical Treatise on the Construction, Care and Management of Modern Locomotives. By Calvin F. Swingle, M. E., Author of the 20th Century Hand Book for Steam Engineers and Electricians; Steam Boilers, their Construction, Care and Management, etc., etc. Chicago, Ill.: Frederick J. Drake & Co. Leather; 4¾ × 6¾ ins.; pp. 630; folding and other plates, and many text illustrations. $3.

The tendency at the present time on our large railroad systems is to establish progressive examinations, covering a period of three years, for the men entering the service as firemen, who ultimately expect to become competent and successful locomotive engineers. Various valuable books on some one or more phases of the work which should be thoroughly understood by every up-to-date locomotive engineer have been published. Mr. Swingle has combined between the covers of one book not only much that has been treated of in the many smaller works, but he has also presented considerable other valuable matter in an original and interesting manner. This book becomes, therefore, a valuable and much-needed source of instruction on nearly all of the essential requisites to become a successful candidate for advancement from the left to the right-hand side of the foot-board.

The general plan of the "Handy-Book" is broadly indicated by the following quotation from the author's introduction.

> The primary or elementary features pertaining to the operation of locomotives will be first taken up, and the discussion will gradually progress through all the various stages in the making of a first-class engineer. A large number of books for engine men are gotten up in the form of a catechism, the answer immediately following the question.
>
> The author believes that the catechetical form is not so helpful as that of having a list of questions but no answers arranged at the close of each chapter. The student is thus constrained to search for the answers, which will always be found in the preceding chapter, and he will thus have the matter more firmly fixed in his mind than he would if he has the answers ready made for him.

The book is presented in an attractive form in flexible covers. The print is large; the illustrations, of which there are many, are clear, simple, and yet comprehensive. In a pocket in the back cover is folded a clearly dimensioned side elevation, erecting drawing, of a Pacific Type Balanced Compound Locomotive. Inserted between the pages in the chapter on automatic air brakes are several large folded plates, giving general arrangements of the principal air brake systems. At the front is a page giving the American Locomotive Co. (Whyte System) Classification of Locomotives.

Chapter I. begins with a somewhat ideal, though very desirable, statement of a fireman's duties, both before and after starting out on the road. Some general instructions as to firing are given, together with descriptions of various types of grates, the steam gage and the safety valve, after which some of the duties of the fireman at the end of the run are set forth. Next follows a plain, readily comprehended discussion of combustion, heat, steam and its various properties. Five pages of tables giving the properties of saturated steam are then presented.

The questions at the end of this, as well as the succeeding chapters, bring out all the salient points in the preceding text. It is safe to say that a faithful student of the book will be exceptionally well posted in the practical and the simpler theoretical features connected with locomotive operation.

The second chapter takes up the general ideas, both practical and theoretical, connected with boilers, their design and construction. Various types of rigid and flexible stay bolts are illustrated, and the necessity for and the methods of staying, supporting, and bracing boiler sheets is clearly indicated, followed by an illustrated description of the methods of applying and expanding boiler tubes. The succeeding sixty pages of this chapter take up in as simple a way as possible the discussion of tensile strength of boiler materials, proportions of rivets and riveted joints, all fully illustrated, and supplemented by convenient tables and rules for calculating the strength of stayed surfaces. It might be properly said that the latter part of this chapter is better adapted to the younger student in a technical school than to the average fireman or locomotive engineer who is not generally supposed to trouble himself as to the rules of design for the boiler which makes the steam for his use.

Chapter III. is devoted to the Throttle and Dry Pipe, showing how the steam is conveyed to the cylinders to perform its work. This chapter is profusely illustrated and gives a clear and very full understanding of the steam dome, the dry pipe, the throttle valve, and the various forms of pipe joints in general use. It also discusses, at length, exhaust pipes and nozzles, including various forms of adjustable nozzles. The latter half of the chapter describes various draft regulating devices in the "front end," and the theory and practical results of their operation. The concluding pages treat of the stack, the petticoat pipe, and the netting.

Valves and Valve Gear are next taken up. A clear description, fully illustrated, is given of the saddle, cylinders and valves of a locomotive having the ordinary type of slide valve and the Stephenson link motion. The common terms, such as lap, lead, clearance, admission and compression are fully explained, and the general principles of the steam distribution by the above means is clearly described. A lucid and complete explanation of the detailed method of setting the valves and adusting the valve gear and its connections is given.

Under Piston Valves and Balanced Valves a discussion of the needs leading up to these improved types of valves is given, and the piston valve, its construction, operation, and setting is described in a simple and original manner. The principles and construction of the leading types of balanced valves is treated at considerable length, and in the closing pages, the latest type for favorable consideration, the Young Valve, on the Corliss principle, is illustrated and carefully described, and data given as to the practical results which were obtained from this type of valve on the Chicago & Northwestern Railway.

Over fifty pages are devoted to the various leading makes of indicators, and directions for their application and use. A large part of this chapter deals with matters more useful to the technical student than to the fireman or locomotive engineer, as it is almost wholly of a purely technical and theoretical character.

In Chapter VIII., on Compound Locomotives, over seventy pages are devoted to a very full description of the various types of compounds used on American railroads, including both their operation and repair. Here again the author has leaned strongly toward the technical and theoretical side of the subject, and has given a discussion which might more properly be used in the class room of a technical school than for the information of actual and prospective locomotive engineers.

Over one hundred and thirty pages are devoted in Chapter IX. to Injectors, Steam Gages, Pop Valves and Other Fittings. Injectors and their principles of operation are described and a detailed description, fully illustrated, is given of most of the leading injectors and their auxiliary attachments, such as the check valves in the feed pipes. Two styles of steam gages, several styles of both open and muffled pop valves, are described and the leading types of up-to-date lubricators. Mechanical bell ringers, sanding apparatus, pneumatic cylinder cocks, and hose strainers are each briefly described. The electric head light is fully dissected, and in connection with it a great deal of valuable practical information is given. This lengthy chapter ends with a quite complete description of the Victor Locomotive Stoker, and also of the Brewer Automatic Fire-door Opener.

Chapter X. will be found of especial practical value to the aspirant for the position of locomotive engineer. Under the heading, "What to Do in Case of Breakdowns" simple practical directions are given for immediate and intelligent action covering the most frequent classes of breakdowns, covering compound as well as simple engines.

Of the two concluding chapters one is devoted to the Westinghouse Air Brake and the other to the New York Air Brake. These brakes are fully described, and the operation of each piece of the apparatus is fully discussed.

Swingle's "Handy-Book" will prove a most valuable helper and guide for the locomotive engineer or fireman who is ambitious to excel in a full knowledge of the locomotive and its practical operation. For some such, the few slightly technical parts will prove of interest and value; for others, such small parts of the book may be omitted without detracting from its general practical value. There are many features in the book which would make it valuable to enterprising engine house mechanics, as well as to shop men. Locomotive shop foremen would, if lacking a technical education, find the "Handy-Book" a source of much valuable help. The book might also prove of practical value to young technical students in connection with their theoretical studies in locomotive design, construction and operation.

*Consulting Engineer, 17 Battery Pl., New York City.

HANDBOOK OF TIMBER PRESERVATION.—By Samuel M. Rowe, M. Am. Soc. C. E. Chicago: The Author (364 Monadnock Block). Leather; 4 × 6¾ ins.; pp. 203; illustrated. $1.

This book is an excellent and complete compendium of information as to modern practice, and its author has had long and varied experience in the preservative treatment of ties and timber. It is notable for the amount of detail in regard to the operation of the plants and records of operation, matters which are usually treated only in a general way in books of this kind. A number of diagrams and tables are given in connection with this part of the work, as well as records of tie renewals and life of ties on several railways. There are also numerous detail drawings of the machinery and equipment for timber treating plants, including studies for the equipment of the timber treating and testing laboratory for the United States government (Bureau of Forestry). Various processes are described in detail, with particulars of the chemicals employed and the time required for the several stages, while complete specifications for the treatment of timber by various processes are also given. The book is closely printed in clear type on thin paper, and is thus very compact and convenient in spite of the amount of material which it contains. Owing to the small size of the pages, however, some of the working drawings, diagrams and tables are so over-reduced that the figures are inconveniently small.

THE RETURN PIPE SYSTEM OF COMPRESSED AIR POWER TRANSMISSION.—By H. C. Behr. A paper read before the Transvaal Institute of Mechanical Engineers. Paper; 7½ × 9½ ins.; pp. 59. Address the Author, P. O. Box 1167, Johannesburg, Transvaal, So. Africa.

Mr. Behr, who is well known to many California engineers, describes in the paper what is known as the Cummings system of compressed air power transmission, invented by Charles Cummings, of San Francisco. The system employs a return pipe for the exhausted air from the motor back to the compressor. A plant on this system installed by the John Wigmore & Sons Co., of Los Angeles, Cal., has been in operation at the Bisbee West Mine, in Bisbee, Ariz., for three or four years.

SLICES FROM A LONG LOAF.—By H. C. Stiefel, Ph. D. Log-Book of an eventful voyage by five Pittsburg tourists down the beautiful Allegheny River, from Oil City to Pittsburg. Pittsburg, Pa.: Bissell Block Publishing Co. Cloth; 5¼ × 8 ins.; pp. 221; illustrated.

A minimum of information about some of the industries of the Pittsburg district is here combined with a story of a boating trip and with a retelling of some other stories, classical and otherwise. The author explains his title by saying that the book, like a loaf, may be sliced into at either end or the middle, as fancy chooses.

Bridge and Structural Design.

Reviewed by Henry S. Jacoby,*

BRIDGE AND STRUCTURAL DESIGN.—By W. Chase Thomson, M. Can. Soc. C. E., Assistant Engineer Dominion Bridge Co., Montreal, Canada. New York: The Engineering News Publishing Co. Cloth; 6 × 9¼ ins.; pp. 88; 76 figures in the text. $2.

It is stated in the preface that this book is the outgrowth of lectures delivered under the auspices of the Dominion Bridge Co., and that the lectures were designed to teach the elements of bridge and structural design in a simple and practical manner. Presumably the lectures were delivered to draftsmen and apprentices.

The text is divided into 22 articles without chapter divisions. Arts. 1-14 relate to elementary mechanics, strength of materials and graphic statics. Since a thorough working knowledge of mechanics is a fundamental requisite for rational designing, it may be well to question the wisdom of an attempt to compress this subject into the narrow limits of 27 pages. The method of presentation in these and in subsequent articles is such that one who has not previously studied mechanics will fail to recognize the limitations under which some of the formulas and rules may be applied. Principles should be clearly stated and their application fully illustrated. "Rules of thumb" soon lead an inexperienced designer into difficulty. Good elementary books on mechanics are now available, the study of which develops a more rational working knowledge.

The articles referred to above are of very unequal value. Those on bending moment and shear are clearly inadequate, while those on center of gravity, moment of inertia and radius of gyration are illustrated by many examples in a satisfactory manner. Lack of care in preparing the text is evident in a number of places. For instance, on page 22, three column formulas are given for some material not designated. The constants used indicate either wrought iron or steel. On that page l represents the length of the column in inches, while on the opposite page the same letter is used in the text to represent feet instead of inches.

Art. 15 is on the design of a Fink rooftruss, 40 ft. in span, supported by the masonry walls of a building, and Art. 17 on that of a similar truss supported by steel columns and knee braces. Both roof trusses are doubtless to be made of steel, although this is not definitely stated.

Art. 18 gives the design of a plate girder, 50 ft. in span, supporting a uniform load of 4,000 lbs. per lin. ft. upon the upper flange, the flanges being assumed to resist the entire bending moment; while in Art. 19 another design is made under the specification that one-eight of the gross section of the web plate be regarded as equivalent flange area. The method is occasionally defective, as in determining the rivet pitch in the flange angles between successive stiffeners, when the average value is computed instead of the minimum pitch.

Art. 20 describes the design of a riveted country highway bridge without sidewalks. The pony Warren trusses have a span of 50 ft. Art. 21 gives the design of a skew bridge of the same kind, but with a span of 72 ft. Art. 22 is on the design of a pin-connected through Pratt truss highway bridge with a span of 120 ft. This is also a light country bridge without sidewalks. A number of its details are regarded in the United States as antiquated. The unequal treatment of important topics referred to above is found also in the computations for the designs. For example, in the pin bridge the computations are given in detail for the design of every pin, together with illustrations showing the packing in each case, while in the design of the U hangers for the floor beams the thickness of the bearing plate is given as though it were arbitrarily adopted, without computing its strength under flexure.

Perhaps enough has been said to show that the book has many faults. If not, some other sins of omission or commission may be noted, as follows: The load used to design the purlin of a roof includes a share of the weight of the truss which supports the purlin (page 28). Under designing field connections no mention is made of the fact that they have less strength than shop riveted connections (page 33). On page 46 it is stated that if it were not for rivet bearing in the flange a 60x¼-in. web plate would be all right, although the web has stiffeners with rivets reducing the net area of the plate that were not considered. On page 68 the required clear width of the bridge is to be 16 ft., but the design shows a width of 17 ft., c to c, of truss, making the clear width less than 16 ft. On page 83 the pin is moved away from the center of gravity of the section without referring to its effect upon the stresses in the upper chord.

To a teacher of bridge design the book is very disappointing, particularly since valuable material from the practical manufacturer's standpoint would naturally be expected in a book written by a person constantly in practice. The reviewer recalls a similar degree of disappointment on only one other occasion— after reading Bowser's book on bridge stresses.

It is to be regretted that so many of the dimensions and stresses marked on the diagrams are practically illegible, even with the aid of a magnifying glass. Since the author is doubtless a constant reader of Engineering News, and hence accustomed to see its excellent reproductions of diagrams, it seems remarkable that most of the drawings prepared for this book should fail to stand the necessary reduction required for the cuts. The eyes of draftsmen are severely taxed by their daily work and therefore especial care should be taken not to add to their burdens by poor illustrations in books intended for evening classes. Some of the lettering is entirely too small; where this is not the case the legibility would be improved by the use of lighter lines and large interior spaces in letters and numerals.

The exterior of the book presents a pleasing appearance, but judged by the usual standard, the price of $2 seems high for a book containing only 94 pages.

*Professor of Bridge Engineering, Cornell University, Ithaca, N. Y.

Natural and Acquired Immunity Against Disease.

IMMUNITY IN INFECTIVE DISEASES.—By Elie Metchnikoff, Foreign Member of the Royal Society of London, Professor at the Pasteur Institute, Paris. Translated from the French by Francis G. Binnie, of the Pathological Department, University of Cambridge. Cambridge, Eng.: The University Press. New York: The Macmillan Co. Cloth; 6¼ × 9¾ ins.; pp. 591; 45 figures in the text. 18s., net; American price, $5.25, net.

From birth to death every one of us harbors countless number of disease germs, and yet most escape a fatal attack from an infective disease for many years and a large proportion of those who reach maturity finally die from some other ailment. Why this freedom or immunity on the part of some for longer or shorter periods, or for a lifetime, and why can it not be made universal and perpetual? To this question, or the first part of it, this noted member of the Pasteur Institute has devoted the large volume before us, a volume composed in no small part of accounts of his own attempts during twenty-five years to solve the mysteries that surround infection and immunity. Beginning with immunity in one-celled organisms the author deals in like manner with multicellular plants and with the animal kingdom. Multitudes of examples are cited to show that from the lowest to the highest forms of life parasitical attacks are resisted through the seizure and digestion of the invader by minute cells within, or in the case of uni-cellular life composing, the organism that acts as the host. The discussion includes a review of the digestive processes in the lower and higher forms of life, and is illustrated by colored photomicrographs in the text.

Five chapters serve to introduce the subjects of natural and acquired immunity in animal life against invasion by pathogenic micro-organisms, or disease germs, and also when once such germs gain a foothold, against the effect of the toxins or poisons which they produce. Under Protective Vaccinations the development of vaccines and antitoxines for twelve diseases of men and other animals are sketched: small-pox, sheep-pox, rabies, rinderpest, anthrax (two forms), swine erysipelas, pleuropneumonia in cattle, typhoid fever, plague, tetanus and diphtheria. Of these most uncertainly seems to attach to the prevention of typhoid fever, but hopeful statistics are cited giving results with Wright's anti-typhoid vaccine during the recent South African War.

A large part of the book is written in such technical language that it can be followed in detail only by the biologist, physiologist and pathologist, but much remains that any student of public health can read with understanding and deep interest. The book as a whole increases one's admiration of such investigators as Pasteur, Koch, Bering, Erlich and the present author, whose lives have been untiringly devoted to the discovery of the cause and control of the germ diseases of man and the lower animals.

The phagocytes, it may be said in conclusion, are the agencies to which, the author and many others believe, we owe such natural protection against infective diseases as we possess. These scavengers, as they have been called, abound in the blood and some other secretions and when a bacterial foe seeks entrance to man or beast through the nose, the mouth, or a wound, it is the function of the scavengers or phagocytes to rush to and surround the invaders, and to absorb and more or less completely digest them. If the phagocytes fail in their task the pathogenic bacteria may multiply and thus cause their specific disease. The opposing theories of immunity are presented by the author in the course of his book, but with the confidence of one who believes that his own theory is now established beyond disproof.

DER EISEN-BETON UND SEINE ANWENDUNG IM BAUWESEN.—Translation into the German of the second edition of "Le Beton Arme et ses Applications." By Paul Christophe, Ingenieur des Ponts et Chaussées Berlin, Germany: Tonindustrie-Zeitung. Leather; 7 × 9½ ins.; pp. 575; 916 figures in the text. 35 marks; American price, $14.

This is a translation of the second (1902) edition of Christophe's well-known work on Reinforced Concrete. The work of the translator, which seems to have been well done, was supplemented by the interest and assistance of the author, who, it is stated, has contributed a considerable amount of supplementary matter, not contained in the second French edition. The mechanical equipment of the work is excellent; clear typography, good paper and a very elaborate binding contribute to its value. The drawings have not, as often occurs, been left untranslated, but are lettered in German.

NOTES ON MECHANICAL DRAWING.—Prepared for the Use of Students in Mechanical Engineering at the University of Pennsylvania. By Horace P. Fry, B. S. in E. E. Philadelphia, Pa. The University. Cloth; 6 × 9 ins.; pp. 55; illustrated. 50 cts.

The matter contained in these notes is intended to supplement the class instruction during the courses in mechanical drawing at the above university. The recognized standards and conventions, as used in American practice, together with tables and other information, are given. The subject is handled in a concise, thoroughly practical manner, and is generally illustrated correctly. The illustrations themselves, while at times not sufficiently reduced and therefore appearing a trifle too coarse, are fairly well executed. Altogether, the "Notes," while elementary in character, will prove of value on the drafting table.

ANNUAL REPORT OF THE STATE ENGINEER AND SURVEYOR OF THE STATE OF NEW YORK.—For the Fiscal Year Ending September 30, 1904. (Henry A. Van Alstyne, State Engineer and Surveyor). Albany, N. Y.: Pub. Doc. Cloth; 6 × 9 ins.; pp. 855; folding and other plates.

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A German Book on Centrifugal Pumps.

Reviewed by Storm Bull.*

ZUR THEORIE DER ZENTRIFUGALPUMPEN.—By Dr. Egon R. v. Grünebaum. Berlin: Julius Springer. Paper; 5½ × 8¾ ins.; pp. 119; three plates and 89 text figures. 3 marks; American price, $1.20.

As the author points out in his introduction, it is but a few years since it was thought that the centrifugal pumps could only be used for very low heads and comparatively large volumes of water. It was not expected at that time to get a high efficiency from a centrifugal pump, and everybody, who is at all familiar with the subject, will testify to the fact that their design was as crude as it possibly could be. At the Paris Exhibition of 1900 two or three firms, especially that of Sulzer Bros., of Winterthur, Switzerland, exhibited centrifugal pumps intended for high head and for which they guaranteed an efficiency of 68 and 70%. To a great many engineers this was quite a revelation, and that exhibition has certainly been a milestone in the road of progress of the centrifugal pumps. The high efficiency and head were obtained by a very careful design of the runner blades, the introduction of guide blades at exit, and by the installation of several runners in one casing and on the same shaft. This method has now been followed by a number of manufacturers in this country, and it is probable that they have obtained as good results as their forerunners in Europe. The great improvements in the centrifugal pump have paved the way for its use in a very large number of circumstances where it would never have been thought of some years ago, and it is but natural therefore that considerable attention should be paid to the centrifugal pump of to-day.

Grünebaum's book is without question the most complete one on this subject so far written. But, as in several recent instances, the reviewer is again of the opinion that the book will be of comparatively small value to the practicing engineer, as the methematical developments are of such a nature that they will frighten most people away. It is, however, an extremely interesting book, and to those who wish to go to the bottom of the subject no other book, so far as the reviewer is aware, can be compared with it. The author discusses all the various phases of the subject, and derives formula which certainly ought to be very useful to all designers of centrifugal pumps. The exact relations between the head, quantity of water and number of revolutions for any pump are derived, and the author proves very conclusively, both by theory and by experiment, that the highest head does not correspond to the smallest quantity of water, as so many have supposed.

The occasion for the writing of the book was the making of a large number of tests of centrifugal pumps for an Austrian firm, many of which are quoted. These, with the graphical representation of the results, form a very interesting part of the book. Some interesting tests of pumps with variously shaped blades are also reported.

The book is made somewhat harder to read by the fact that it presupposes a knowledge of Zeuner's "Theory of Turbines." This latter book is of course the best book on this subject, but it is, if the reviewer is correctly informed, comparatively little known in this country. To one who is familiar with it the reading of Grünebaum's book will seem quite familiar, as exactly the same notation is used in both, and a number of the fundamental formulas are taken from Zeuner's book. This fact leads the reviewer to remark that it shows very plainly the close relation between the centrifugal pump and the turbine, and, further, that it is principally because the same close attention has not been paid to the proper design of the blades—both in the runner and in the guide wheel—of the centrifugal pump as of the turbine, that such poor efficiencies have been obtained for the centrifugal pump as built until a few years ago.

In closing, the reviewer desires again to state that this book is a very valuable addition to the literature on the subject, and if one is not frightened by such mathematical references as the intersection of a hyperbolic paraboloid with an elliptical hyperboloid, the reader will without question be well repaid by a close study of the book.

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

Municipal Ownership and the Single Tax.

THE CITY.—The Hope of Democracy. By Frederic C. Howe, Ph. D., Author of "Taxation and Taxes in the United States under the Internal Revenue System." New York: Charles Scribner's Sons. Cloth; 5½ × 8¼ ins.; pp. 319. $1.50, net.

Mr. Howe's study of city problems in their relation to democratic institutions and the welfare of the masses is a notable contribution to municipal literature. He calls his treatment of the subject a "reversal of method," because he holds that municipal reform and the general uplift of the mass of city dwellers depends primarily on industrial and economic changes, or we might say revolutions, rather than upon charter revisions, a higher class of men for city officials, or an improvement in the personal morals and intelligence of the citizens. To bring out his ideas the author reviews the growth of cities in population and in public activities, the advantages and disadvantages of city life, the workings of the American city of to-day, the source of municipal corruption, the boss and the party, and the benefits of the municipal ownership. He also discusses, among other topics, the "Cost of the Slum," the human wreckage incident to city life, the appreciation in value of city real estate and the revenues of the city.

The bane of city government, our author holds, is "Privilege," or valuable franchise grants to corporations which fatten on the needs of city dwellers, and, to make sure of the continuance of their huge and unjust profits, control the membership and the policy of city governments. The remedy is the abolishment of privilege and the substitution of municipal ownership. This change, our author holds, would not only purify politics and make for a better city government generally, but it would also greatly lessen the burdens of the poor, who are overcharged for the services rendered by franchise companies.

The city treasury might be filled, Mr. Howe urges, and that so full as to enable the city to do much for the education, moral uplift and general improvement of the poor, by taxing land values instead of buildings and personal property; and this at the same time would encourage more ample and cheaper housing facilities for all.

Baldly stated, Mr. Howe's two great city reform measures are municipal ownership and the single tax. But the book is far more than a plea for municipal ownership and the single tax. Mr. Howe's one great object is to point the way to the ideal city, both in government and in living conditions. If, in striving to do this, he has been one-sided, as he doubtless has, this is not wholly without advantage, since extreme views often bring the various aspects of a subject into such bold relief as to make for clearness and, by stimulating argument in rebuttal, for ultimate truth.

Mr. Howe's main arguments in favor of municipal ownership are strong, and much of his abstract reasoning in favor of the single tax is well put, although less convincing to most people, but the author is too sweeping in his advocacy of the adoption of these measures and in his claims for resulting benefits.

In depicting the abuses due to the greed and high-handedness of private capital the author forgets the moral and mental defects and delinquencies, to put it mildly, of the great mass of the people who so far outnumber the voting strength of the so-called privileged class and its dependents. The ideal city depends not upon one or two lines of public policy, such as municipal ownership and taxation, but upon many questions of public policy, and, far above all, on the conscience and intelligence of the mass of the citizens.

Steam Power Plant Data Book.

Reviewed by Storm Bull.*

STEAM POWER PLANT.—Power Plant Papers, Form I. Prof. C. E. Lucke, Columbia University. New York: D. Van Nostrand Co. Paper; 8 × 13 ins.; pp. 70 (double). $1.50.

The reviewer understands that this book is to be used for a double purpose: (1) For recording professional inspections by mechanical engineers; (2) for recording the same data by students required to present a memoir on this subject in the summer of their third college year.

There is no question but that the enumeration of the data, with spaces to be filled out, is a very complete one. In fact, the enumeration goes into such details that the reviewer is very much afraid that even a professional man will never be able to cover the ground entirely. But it is very willingly admitted that such a book will greatly help to make an investigation of a steam power plant complete, as spaces for all the data which possibly might be desirable are to be found in the book.

When the use of the book by students at the end of the junior year is considered, the reviewer cannot help coming to the conclusion that the very large number of data to be sought will be rather bewildering to the average student; and in fact a great many of the data are altogether beyond his horizon or his capacity. This latter refers especially to the large number of data regarding the cost of installation and of operation. Who, for instance, would expect a student at the end of the junior year to report correctly on "the ratio of installation cost of non-exhaust system to same for auxiliaries?" or "the ratio of material cost to labor cost for steam branches?"

The price, $1.50 per copy, is also, it would seem, too high, and certainly very much too high for students, as much more than half of the spaces left to be filled out will be left blank, either because of the absence of the particular apparatus in a power plant or because of the inability of the students to comprehend or obtain the data sought.

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A Pocket Book in Fact.

Reviewed by Amasa Trowbridge.*

A POCKET-BOOK OF MECHANICAL ENGINEERING. Tables, Data, Formulas, Theory and Examples. For Engineers and Students. By Charles M. Sames, B. Sc. Jersey City, N. J.: Charles M. Sames. Leather; 4 x 6¾ ins.; pp. 168; 37 figures in the text. $1.50.

Designed to furnish, in a very compact form, the necessary data and formulas for mechanical engineers and students in that subject, this little book actually meets, in a great measure, a very different need. Its real use is probably to be found as a supplementary pocket-book for engineers whose line of work is mostly outside the distinctly mechanical branch of engineering. For instance, a civil engineer sometimes needs information that is not to be found in Trautwine and would really be out of place in that excellent book. He does not, perhaps, think it worth while to buy one of the very complete mechanical engineering pocket-books that are to be had, and depends on borrowing one for each occasion. Such a procedure is sure to cost something in time and inconvenience, and the information, when found, must be copied, as the book must be returned immediately. The information would, in all probability, be found in sufficient detail in Mr. Sames' little book, and it is such an inexpensive book that it would be as cheap to buy it as to borrow it. The book will also be found useful by superintendents, foremen and men who must carry their technical library in their pocket.

This little volume is the most compact reference book the reviewer has ever seen. It contains, in a very condensed form, most of the data and formulas to be found in the larger pocket-books and some data not found in them. Of course, where the matter is so compact, comparative formulas cannot be given, so the author has been compelled to choose the one most apt to fit the majority of cases. This is just as well in case an engineer has not enough experience to make a wise choice and, if he be experienced enough for that, he would probably be able to correct any small errors that crept into his calculations from the use of a formula that was not exactly the best for his conditions.

For an engineer who is called on to make trips away from the office on emergency work, or for one who is traveling a great deal, and wants a "pocket" book in fact, this book will admirably serve the purpose. It contains the general formulas that are needed for engineering work and the tables of properties of steel shapes, strengths of materials, weights, etc. Quite a number of data for estimates are given which have not appeared in other mechanical engineering pocket-books, and this is extremely valuable to the man away from the office. In fact, it is a fairly complete reference book.

The most complete treatment in the book is on electricity, 31 pages, or nearly one-fifth of the book being devoted to it. Internal-combustion engines are treated, quite efficiently, in five pages, steam turbines in two and locomotives in three pages. Boilers, their accessories and incrustation, are treated in eight pages. This gives, to an engineer, a pretty good idea of the boiling-down that has been done to make the book so compact, and it is just this boiling-down that makes the book inadequate for all the needs of the mechanical engineer or student in that branch. For the regular mechanical engineer, a much more complete book, giving the matter in greater detail, and giving more exact particulars, is a necessity. Likewise, a student should not be initiated with such a book, as it would almost surely give him the idea that one formula could be used, say in steam engine design, for all classes of work: high-speed, low-speed or intermediate. Then, too, a beginner wants more information than this little book gives. He needs a standard with which to compare the results he obtains from his experiments, and hence must know the conditions under which the data given in his hand-book were found. He also needs a variety of formulas, each adapted to a specific case, so

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that he may not have to draw on his inexperience for modifying factors.

A very serious fault in the book is the use of a "factor-of-safety" in the formulas for the strength of materials, instead of using an "allowable fiber-stress." There are also some misstatements; as, on page 57, "cast iron expands when solidifying." If that were only true, it would be much easier to get sound castings. On page 76, the absolute temperature corresponding to 32° F. is given as 492° in the text and as 493° in the figure. A small mistake, but one that might lead to a misunderstanding.

The book appears to be pretty well indexed, which is one of the most important points in a reference book, and its small size makes it very easy to find any information desired; but the indexing might with profit have been carried much farther. Space devoted to an elaborate index is not wasted when it makes it easier to find what is wanted in a hurry, and every man who uses such a book can appreciate this.

The man who wants a small, compact pocket-book on mechanical engineering for occasional use, will find this one sufficient for his needs, but it cannot satisfy the requirements of the practicing mechanical engineer.

College Machine Design.

Reviewed by Chas. R. Pratt.*

MACHINE DESIGN.—By Albert W. Smith, Director of Sibley College, Cornell University, and Guido H. Marx, Associate Professor of Mechanical Engineering, Leland Stanford Junior University. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6 × 9¼ ins.; pp. 339; 31 tables and 279 figures in the text. $3.

Briefly characterized, this is a college treatise, broad and elementary in its introduction, thorough in detail, elaborate in formulas, limited in references to modern devices and inaccurate in some of its practical data.

It treats in logical sequence the elements of mechanism and machine design, followed by construction in detail of machinery, and an excellent chapter on "Riveted Joints." It is well written and illustrated, and the effort to lead elementary conception into actual construction is consistently followed out, giving the reader, or the student, the satisfaction of learning the means and the reason for the result obtained.

Designing machinery by arbitrary rules is blind drudgery; but with a clear and keen appreciation of functional utility, with full confidence of knowledge to produce functional results, machine design from basic conception to minute detail is a pleasure. Mental or physical fatigue is an indication of misdirected or overtaxed energy; the best results are accomplished with the least conscious effort, success is timed by short hours. It is encouraging to observe that this principle is being developed in modern college education, by such books as this on "Machine Design."

Passing from general to specific criticism, the latter based on the personal experience of the reviewer, a number of errors and deficiencies may be noted. Arbitrary reasons are given (page 76) for making all cast beams elliptical in section, but the I or box section is usually the best for cast beams. Table VII. (page 134) gives "'K,' allowable pressure per square inch of projected thread area" for nuts at various speeds, but ignores the length of time these speeds are maintained. As most nuts act intermittently, doing work less than 1% of the time, "K" would not drop from 3,000 to 250 lbs. while the speed increased from 50 to 400 ft. per minute. Table VIII., on the same page, gives coefficients of friction about half those obtained in commercial practice.

Table XVII., on page 186, gives only 50 lbs. per sq. in. at 200 ft. per min. mean velocity of rubbing surfaces for a thrust bearing submerged in oil, steel against bronze, as against 500 lbs. per sq. in. at 250 ft. per min. in Table VII., for nut threads. At continual duty, such a thrust bearing would do twice the work per square inch that any nut could do. Neither of these figures is correct. Thrust bearings as here described carry safely loads of 1,000 lbs. per sq. in. at speeds of 500 ft. per min.

The remarks on Taper Keys (articles 102-3, page 141) apply more properly to repair work in a country machine shop than to modern machine design.

If the authors (page 203) will refer again to the "American Machinist," June 27, 1901, they will find an article by the reviewer, showing that within a given space short rollers will transmit more power in a thrust bearing than any other form of rolling or sliding friction, and, properly designed, are as efficient as are balls for heavy pressures. Unreliable data for loading for balls is given on page 206.

Under the article headed "Design of Worm Gears" (page 300) it is stated that a rubbing speed of 300 ft. per min. is dangerous and that 1,000 ft. per min. is impracticable; whereas the worm gears in electric elevators, which comprise by far the greater number of worm gears that are in use for any power purposes, have rubbing speeds of from 600 to 1,000 ft. per min. Table XXX. ignores the main factor of the capacity of a worm gear, and that is the circular pitch.

The section on "Springs" (page 308) is incomplete for a book of this size and character. A helical spring table should have been included, like the one in Kent's Hand Book, or at the least a reference to such a table should have been given. Helical springs from any reliable spring maker will not vary 5% from Kent's table, and often come within 1%.

The foregoing criticisms illustrate the difference between data obtained in practical engineering and in college work. They also indicate that no one or two men are competent either to write or review such a book as this one, particularly since the criticisms have been confined to such topics treated in the book as are within the personal experience of the reviewer.

The authors recognize, in their excellent introduction, the extent to which theory is governed by practice and the impossibility of embodying in a book the judgment of the man on the job.

Specialization in both mental and manual effort gives rise to a demand for specialized text books for engineers and restricts to college use books of broader scope. Unfortunately there are fewer writers able and willing to meet the wants of engineers than to supply the needs of college students. It is to the latter that this book on Machine Design is addressed, and for them it will serve as a general introduction to a field where experience will temper knowledge with judgment.

*Consulting Engineer, 160 Fifth Ave., New York City.

Earthwork Tables.

Reviewed by Halbert P. Gillette.*

EARTHWORK TABLES.—By R. S. Henderson. Part I. Preliminary Earthwork Tables, Giving Cubic Yards per 100 Feet for Level Sections, to which is added a Graphical Method of Estimating Quantities from a Profile. Part II. Earthwork Tables, Giving the Volume in Cubic Yards of Prismoids 100 Feet Long by the Average End Area Method. New York: The Engineering News Publishing Co. Stiff paper; 12¼ × 9¼ ins.; pp. 32. $1.

This is a very useful book of tables. In this Supplement for Jan. 15, 1903, there appeared a review of twelve books of tables and diagrams for calculating earth quantities. One of the books discussed in that article, namely, Cross's "Engineers' Field Book," has since gone out of print. This new book by Henderson, now under review, is the literary successor of Cross, in so far as one of its earthwork tables is concerned. But Henderson's work is much more complete, and correspondingly more satisfactory.

Henderson's tables are divided into two parts. Part I. is entitled "Preliminary Earthwork Tables," and gives the yardage per station for level sections. These tables are exceptionally complete in that they give the yardage for all widths of roadbed (or base) from 1 ft. up to 50 ft., varying by 1 ft. This enables the engineer to calculate the yardage of a small ditch (having, say, 2-ft. base), or the yardage of a four-track road with equal facility. It is true that the tables apply directly to slopes of 1½ to 1, only, but, by one addition or subtraction, the yardage can be calculated for any one of the following slopes: 1¼ to 1, 1 to 1, ½ to 1, ¼ to 1 and vertical. The table does not give fractions of a cubic yard, but only the nearest yards. This is sufficiently close for preliminary estimates. Up to 25 ft. the table gives yardage for cuts or fills varying by 0.1-ft. Between 25 ft. and 50 ft. the yardage is given for cuts varying by 0.5-ft. Between 50 ft. and 100 ft. the cuts vary by 1 ft. As can be seen, this table is very complete. Indeed, the reviewer knows of no other similar table that equals it for range.

Part II. gives the yardage of prismoids 100 ft. long by the average end area method. This is the part that resembles Cross's tables above mentioned. In using this table, add the end areas together and look in the table for the number of cubic yards corresponding to the sum so obtained. Sums of end areas up to 1,000 sq. ft. vary by hundredths, and cubic yards are given to the nearest hundredth. Sums of end areas up to 10,000 sq. ft. vary by tenths, and cubic yards are given to the nearest tenth. This table covers a wide range and is very compact. The author has devised an ingenious expedient for securing this compactness, which is difficult to explain, however, without a sample page of the tables for illustration. Instead of placing the sums of the end areas in the left-hand column, as is the common practice, he places the sums in the body of the table. The writer likes this arrangement, especially because of the remarkable compactness that results from it.

Now, a word as to tables in general for computing yardage from the end areas. Many engineers claim that it is useless to compute end areas at all, since it is often possible to compute yardage direct from the cuts or fills. This is true of three-level sections, but the reviewer's experience has been that a vast amount of work involves more than three rod readings taken at each station. When it happens that more than

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In the second part will be found information and data about matters connected with turbine plants.

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YEARBOOK OF LEGISLATION, 1904.—Edited by Robert H. Whitten, Sociology Librarian. Legislation Bulletin 23, Digest of Governors' Messages, 1904; 24, Summary and Index of Legislation, 1904; 25, Review of Legislation, 1904. New York State Library: Melvil Dewey, Director. Albany, N. Y.: Pub. Doc. Cloth; 5¼ × 9 ins.; not paged. $1.

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STATE SUPERVISION AND STATE AID.—By Sam Huston. Bulletin No. 4, Highway Department, State of Ohio. Sam Huston, Commissioner. Columbus, O.: Pub. Doc. Paper; 6½ × 9½ ins.; pp. 50.

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ANNUAL REPORT OF THE SOUTH AUSTRALIAN RAILWAYS COMMISSIONER.—For the Year 1904-5. Alan G. Pendleton, Railways Commissioner.) Adelaide, South Australia: Pub. Doc. Paper; 8⅛ × 13⅛ ins.; pp. 54; two diagrams and one folding map. Also Tables accompanying Report of Alex. B. Moncrieff, Engineer-in-Chief of Railways. Pp. 47.

BETON-KALENDAR, 1906.—Pocketbook for Concrete and Reinforced Concrete Construction, and Related Branches. Published by "Beton und Eisen," with the cooperation of prominent experts. First issue. Berlin, Germany: Wilhelm Ernst & Son. Cloth; 4 × 6½ ins., pp. 206 + 338 + 72; over 650 figures in the text. 3 marks; American price, $1.20.

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